The Engineer

FEBRUARY 27, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

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ANGLO-IRANIAN OIL COMPANY'S
KENT REFINERY, ISLE OF GRAIN
The illustration shows a Larssen box pile, 111 ft. long, being pitched through one of the temporary openings in the concrete deck of the jetty.
Over 2,500 tons of box piles, Larssen Section B.P.4, have been driven vertically and at a rake of 1 in 2½ for the four jetties.
The B.S.P. diesel-operated pile-driving plant is seen on the right.
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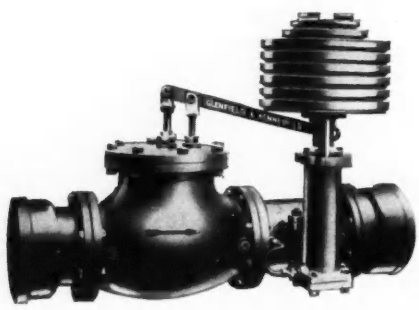

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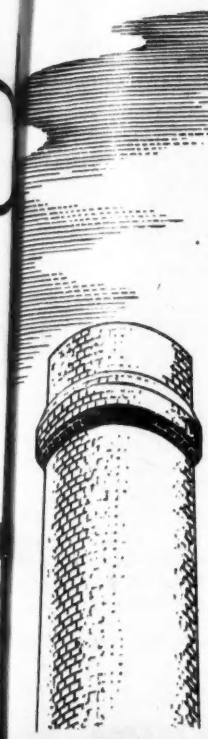

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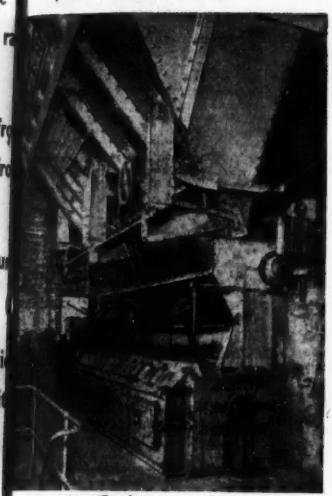

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

GLAMORGAN EDUCATION COMMITTEE

GLAMORGAN TECHNICAL COLLEGE

LECTURERS

Required at the Glamorgan Technical College, Treforest :—
(a) Lecturer in Mine Surveying,
(b) Senior Lecturer in Electrical Engineering,
(c Lecturer in Mechanical Engineering.

For (a) and (b) duties to commence on 1st May and for (c) on 1st September, 1953, or as soon as possible thereafter. Candidates, who should have had experience in teaching, together with experience in industry and/or research, must possess the following qualifications :—

For (a) the Mines Surveyor's Certificate of Competency of the Ministry of Fuel and Power, together with one or more of : a University Degree in Mining Engineering, the First Class Certificate of Competency (Colliery Managers), Associate Membership of the Royal Institution of Chartered Surveyors, and must be capable of teaching surveying to mining and civil engineering students to degree standard.

For (b) an Honours Degree or equivalent professional qualification, preferably with a Higher Degree. The successful candidate will be responsible to the Head of the Engineering Department for the organisation and teaching of electrical engineering in the Department. Some experience in the industrial application of electronics will be an advantage.

For (c) an Honours Degree in Mechanical Engineering or an equivalent professional qualification. Ability to teach theory of machines and machine design plus one other subject to degree and diploma standard is desirable.

Salaries in accordance with the Burnham Technical Award, viz., Lecturers, £900 by £25 to £1000 plus £40 special addition to salary ; Senior Lecturers, £1000 by £25 to £1150 plus £40 special addition to salary.

Application forms, obtainable from the undersigned, must be returned not later than 7th March, 1953.

EMLYN STEPHENS,
Director of Education.

County Hall, Cardiff. E7469

BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal : G. E. WATTS, M.A., Ph.D. (Cantab.), B.Sc. (Lond.), F.R.I.C.

ASSISTANT LECTURER

ASSISTANT LECTURER (Grade B) in Production Engineering required for work up to H.N.C. standard. Salary £490 by £25 to £765, plus £60 for graduate or equivalent qualification. Increments allowed for approved industrial and/or teaching experience.

Further particulars and application forms obtainable from the undersigned on receipt of stamped, addressed foolscap envelope. Completed forms to be returned to the Principal, Brighton Technical College, Brighton, 7, within fourteen days.

W. G. STONE,
Education Officer.

54, Old Steine,
Brighton. E7475

WARRINGTON EDUCATION COMMITTEE

TECHNICAL COLLEGE, PALMYRA SQUARE

ASSISTANT IN MECHANICAL ENGINEERING, GRADE B

Applications are invited for the above post from candidates with Degree or equivalent qualifications and suitable industrial experience. The successful candidate will be required to teach workshop subjects to City and Guilds courses and up to H.N.C. standard.

Salary will be in accordance with Burnham Scale, Grade B, namely, £490–£765, starting point being determined by qualifications and experience.

Forms of application may be obtained from the undersigned upon receipt of a stamped, addressed, foolscap envelope, and should be returned within fourteen days of the appearance of this advertisement.

H. M. PHILLIPSON,
Chief Education Officer.

Education Office,
Sankey Street,
Warrington. E7485

COLLEGE OF TECHNOLOGY, BIRMINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

HEADSHIP

Applications are invited for the above post, which becomes vacant from 1st September, 1953. Applicants should possess, in addition to appropriate academic and teaching experience, also industrial and research experience.

Salary will be in accordance with the Burnham (Further Education) Scale for a Grade V Headship, £1490 by £25 to £1640.

Forms of application and details and duties of the post may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1.

Closing date for applications is 20th March, 1953.

C. McCAW,
Clerk to the Governing Body.

E7482

PUBLIC APPOINTMENTS

LONDON COUNTY COUNCIL

WANDSWORTH TECHNICAL COLLEGE

HEAD OF ELECTRICAL ENGINEERING DEPARTMENT

To commence September, 1953, HEAD of ELECTRICAL ENGINEERING DEPARTMENT, which comprises part-time day and evening classes in electrical engineering to Higher National Certificate standard, together with trade and City and Guilds courses. Applicants should hold a Degree in Electrical Engineering and Corporate Membership of an Engineering Institution. Industrial and technical teaching experience essential. Burnham salary : Grade II, Head of Department, £1040 by £25 to £1190 plus London allowance.—Particulars and application form from the Secretary at the College, Wandsworth High Street, S.W.18, for return by 18th March. (147) E7471

ROYAL CORPS OF NAVAL CONSTRUCTORS

ENTRY FROM PRIVATE SHIPYARDS AND UNIVERSITY

GRADUATES IN NAVAL ARCHITECTURE

A COMPETITIVE EXAMINATION for entry into the Royal Corps of Naval Constructors will be held in June, 1953. Accepted candidates will be entered as Probationers in the Royal Corps and will receive a course of training mainly at the Royal Naval College, Greenwich. Candidates must be not more than 26 years of age on 1st October, 1953, and (except for graduates) must have been engaged in practical shipbuilding for at least eighteen months before entry. Graduates of the Universities are preferred and in their case a period of practical experience of less than eighteen months may be accepted.

2. Full particulars may be obtained upon application to the Secretary of the Admiralty (C.E. Branch), Bath. Intending candidates must send to that address, before the 1st April, full particulars of their education and technical training, and of their practical experience.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE

In conjunction with the above a QUALIFYING EXAMINATION will be held for Private Students who desire to take the same course as that prescribed for Officers of the Royal Corps of Naval Constructors under training. Candidates' applications should reach the Secretary of the Admiralty (C.E. Branch), Bath, before the 1st April. A fee of £50 per session is at present payable by private students taking this course, but the amount payable is under review. E7494

SURREY COUNTY COUNCIL

COUNTY ARCHITECT'S DEPARTMENT

MECHANICAL ENGINEERING ASSISTANT

Applications are invited for the appointment of MECHANICAL ENGINEERING ASSISTANT, Grade V, at a commencing salary of £595 per annum, rising by annual increments of £15/£20 to a maximum of £645 per annum, plus London allowance of up to £30 per annum, according to age.

Applicants should have good technical training and experience in the design and preparation of drawings, specifications and estimates for installations of heating, ventilating and hot water supply services in large buildings.

Preference will be given to Members of the Institution of Heating and Ventilating Engineers.

The appointment will be subject to the provisions of the Local Government Act, 1937, and the successful applicant will be required to pass a medical examination.

Applications, stating age, qualifications and experience, and accompanied by copies of three recent testimonials, should be sent to the County Architect, Surrey County Council, County Hall, Kingston-upon-Thames, not later than the 7th March, 1953.

Canvassing, either directly or indirectly, will disqualify a candidate from consideration.

The Council will be unable to provide any housing accommodation and the successful applicant will be expected to make his own arrangements in this direction.

W. W. RUFF
Clerk of the Council.

County Hall,
Kingston-upon-Thames. E7476

BRITISH ELECTRICITY AUTHORITY

SOUTH EASTERN DIVISION

ASSISTANT ENGINEER (HANDLING)

Brighton " A " and " B " Power Station. ASSISTANT ENGINEER (Handling). Applicants, who should possess a knowledge of shipping, coal storage and its associated problems, will be responsible for the operation of the coal and ash-handling plant and associated equipment, including mobile equipment. Experience in the control of labour is essential. Class " L," Grade 12, £667 per annum.

Croydon " B " Power Station. JUNIOR ENGINEERS (Control). Applicants should preferably possess education qualifications equivalent to Higher National Certificate and should have had experience in the operation of E.H.T. switchgear and parallel running of alternators. Class " J," Grades 18/14, commencing at £415 per annum, including London allowance. N.J.B. Conditions of Service for both positions.

Applications, giving details of present position, education, experience, &c., should be received by either Station Superintendent, Brighton Power Station, Portslade-by-Sea ; or Station Superintendent, Croydon " B " Power Station, Beddington Farm Lane, Purley Way, Croydon, Surrey, not later than 9th March. E7541

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY BOARD

FEDERATION OF MALAYA

ELECTRICAL ENGINEER FOR HYDRO-ELECTRIC WORK, ASSISTANT POWER STATION SUPERINTENDENT, OPERATION & EFFICIENCY ENGINEER

ELECTRICAL ENGINEER for Hydro-Electric Work (M.25728.B.), ASSISTANT POWER STATION SUPERINTENDENT (M.28769.B.), and OPERATION and EFFICIENCY ENGINEER (M.28770.B.) required by the Central Electricity Board, Federation of Malaya. Option of appointment either (a) on agreement for three years in the first instance leading, subject to satisfactory service, to an offer of permanent employment on the pensionable establishment, with opportunity of terminating appointment at the end of the first year's service, if so desired ; or (b) on contract for three years with a gratuity at the rate of £50 or £70 for each completed period of three months' service, according to salary. Allowances, additional to those mentioned below, ranging between £210 and £630 a year, are payable to married men according to salary and dependants. Free passages. Liberal leave on full salary.

Electrical Engineer for Hydro-Electric Work. Salary (including allowances) payable in local currency, equivalent at present Government rate of exchange to £1218, rising to £2100 a year. Commencing salary according to age, war service and experience. Candidates must be able to carry out preliminary investigations for hydro-electric schemes, to arrange for surveys for projected schemes, to prepare designs and contracts for small schemes up to 10,000kW and to supervise the construction of the works. They should preferably be Corporate Members of the Institution of Civil Engineers or possess qualifications carrying exemption from Sections A and B of the Institution's examination. Those who are not so qualified would be eligible for salary on a lower scale equivalent to £1197, rising to £1862 a year (including allowances).

Assistant Power Station Superintendent. Salary (including allowances) payable in local currency, equivalent at present Government rate of exchange to £1904, rising to £2100 a year. Candidates must have wide experience of station maintenance and operation and preferably have held a similar position in a steam power station of not less than 80MW capacity or as a charge engineer for at least five years in a station of not less than 120MW capacity.

Operation and Efficiency Engineer. Salary (including allowances) payable in local currency equivalent at present Government rate of exchange to £1687, rising to £2100 a year. Candidates must have had good power station experience, including some years as a charge engineer in a modern steam station, and have a knowledge of the principles of combustion, thermal cycles and heat balances, system control, and the economics of operation. Candidates should preferably be Corporate Members or Graduates of the Institutions of Electrical or Mechanical Engineers or hold an equivalent qualification. Those who are not so qualified would be eligible for salary on a lower scale equivalent to £1673, rising to £1862 a year.

Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience, and mentioning this paper, to the Crown Agents for the Colonies, 4, Millbank, London, S.W.1, quoting on letter the reference number against the appointment for which application is made. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration. E7513

COUNTY BOROUGH OF PRESTON

PORT OF PRESTON AUTHORITY

APPOINTMENT OF ENGINEERING ASSISTANT

Applications are invited for the above appointment on the staff of the Engineer at a salary in accordance with Grade A.P.T. V of the National Scale of Salaries (£595–£645 per annum).

Applicants should have passed Final Parts I and II of the Institution of Civil Engineers' examination and should have experience in the design and execution of civil engineering work and building construction and be competent surveyors.

The appointment is subject to the Local Government Superannuation Act, 1937, and the National Scheme of Conditions of Service. The successful candidate will be required to pass a medical examination.

Application forms and conditions of service may be obtained from the undersigned, to whom they should be returned, endorsed " Engineering Assistant," not later than the 5th March, 1953.

W. E. E. LOCKLEY,
Town Clerk.

Municipal Building,
Preston. E7483

BRITISH ELECTRICITY AUTHORITY

RESEARCH LABORATORIES

SCIENTIFIC STAFF

SCIENTIFIC STAFF, Research Laboratories, Leatherhead. Candidates should have a First or Second Class Honours Degree in Electrical or Mechanical Engineering or in Physics and preferably some research experience. Duties include testing, development and research work in the laboratories and in the field in connection with the generation, transmission and distribution of electricity. Appointments, which are superannuable, will be made within the following N.J.B. grades, according to qualifications and experience :—

Second Assistant, Grade 3, £800–£1159.
Third Assistant, Grade 4, £717–£934.

Forms from D. Moffat, Director of Establishments, British Electricity House, Winsley Street, London, W.1, to be returned by March 23rd, 1953. Quote reference AE/337. E7470

PUBLIC APPOINTMENTS

CROWN AGENTS FOR T... COLONIES

LAGOS TOWN COUNCIL, NIG...

ASSISTANT ENGINEER

ASSISTANT ENGINEER required by ... Town Council, Nigeria. Applications ... from persons who are (a) Corporate Memb... Institution of Civil Engineers, or (b) p... Engineering Degree or Diploma recognised ... ing exemption from Sections A and B of ... tution of Civil Engineers' examinations, and ... two years' practical experience of civil or ... engineer work. Age to be 35 or under. Sal... by £40 to £1290. (Persons not from We... receive pensionable expatriation pay of £1... to £270.) Transport allowance payable ; £... allowance payable on first appointment.

Tours of service are of 12 to 18 months' ... Leave is five days per month worked (seven ... case of expatriate officers). Expatriate ... receive free passages for self and wife and f... quarters at a rent of 10 per cent of basic ... Officers can retire on pension between 45 ... Officers receive free medical attendance, ... pass medical examination on first appointme...

Apply at once by letter, stating age, full n... block letters, and full particulars of qualifi... and experience, and mentioning this paper, ... Crown Agents for the Colonies, 4, Millbank, ... S.W.1, quoting on letter M.29822.D. The ... Agents cannot undertake to acknowledge all ... tions and will communicate only with ap... selected for further consideration.

THE BRITISH COTTON INDU... RESEARCH ASSOCIATION (SHIRLEY INSTITUTE)

HEAD OF SPINNING DEPARTM...

Physicists, Research Engineers and ... Scientists are invited to apply for the pos... HEAD of the SPINNING DEPARTMENT ... Shirley Institute. The Department, wh... present has a staff of about sixty, engages in r... into the processes and products of the cotton s... industry, and into the development of new ma... It deals with cotton, silk, rayon and synthetic ... and provides technical services to the various ... tries that use cotton spinning machinery. ... Head is required to superintend all the activ... the Department, to help with the presentat... results to the scientific world and to the indust... to help in the formulation of research and d... ment policy. There is an extensive program... long-term research, and it is important that th... should be able to influence considerably the ... of this work. The Department is adequately ... with people having knowledge of the indust... its technology and knowledge of textiles ... essential. Candidates will therefore be con... primarily for their qualities of leadership, in... and judgment, and for their qualifications and ... ence as research scientists. A salary of up to ... per annum will be paid, with participation ... Federated Superannuation System for Univers... Applications should be made to Dr. Toy, Dire... Research, Shirley Institute, Didsbury, Manches... E...

ULSTER TRANSPORT AUTHO...

DEPUTY CHIEF ENGINEER

The Authority invites applications for the ap... ment of a CHIEF ASSISTANT to the Chief ... neer.

Applicants should be Engineering Graduate... recognised University or Corporate Members ... Institution of Civil Engineers, the Institutio... Mechanical Engineers or the Institution of Elec... Engineers, or having equivalent qualifications, ... not exceeding 40–45 years of age.

Candidates must have had experience in ... sponsible position embracing rolling stock ... tenance practice, workshop and depot design, ... shop practice, planning and management.

The post will involve responsibility for design, ... struction and maintenance of permanent way, ... trical and telecommunications, road tra... vehicles, motive power units for heavy traction ... including diesel locomotives and multi-engined ... trains.

Commencing salary will be £1600 per annum. ... Applications should reach the undersigned ... later than 9th March, 1953.

T. B. ANDISON,
Secret...

21, Linenhall Street,
Belfast. E...

NATIONAL COAL BOARD

ENGINEERING BRANCH OF PRODUCTION DEPARTMENT

HEAD OF THE STANDARDISATIO... SECTION

National Coal Board invite applications f... superannuable appointment as HEAD of ... STANDARDISATION SECTION in the Engi... ing Branch of Production Department at L... Headquarters. Salary range £1100 to £15... clusive, according to qualifications and experie...

Candidates should preferably be mechanical ... neers who have had drawing-office experience a... experience in standardisation work. Some ... mercial experience would be an advantage.

Write, giving full particulars (in chronolo... order) of age, education, qualifications and exper... (with dates), to National Coal Board, Establish... (Personnel), Hobart House, Grosvenor P... London, S.W.1, marking envelope TT/599. Or... testimonials should not be forwarded. Closing ... 14th April, 1953. E...

THE ENGINEER

FEBRUARY 27, 1953

Chamber of Shipping Annual Report

THIS week the Chamber of Shipping of the United Kingdom issued its annual report for 1952–53. The international outlook, with the Korean War in its third year, remains unsettled, the report states, and defence measures have meant restriction on industrial output, which will eventually have its effect on Great Britain, dependent for its life upon an overseas trade. The danger signals are clear, ex-enemy countries have re-established themselves as competitors and some British goods are being priced out of foreign markets; in addition, the growth of the merchant fleets of certain nations has increased the rivalry in sea transport and the difficulties of countries dependent on shipping as a principal industry. With reference to the Suez Canal, the report states that the dislocation by the shortage of pilots and the withdrawal of Egyptian labour has disappeared. Statistical tables, included in the report, show that world merchant tonnage has increased by 3,000,000 tons during the year to 83,500,000 gross tons, but the size of the United Kingdom fleet remains practically the same. New liner tonnage is balanced by disposals and the increase in tanker tonnage is more than offset by the fall in tramp tonnage, a factor which is disturbing. Of the ships under construction half are on tanker account, about one-quarter are cargo liners, and only one-tenth are tramps and the report goes on to discuss the high building costs, commercial uncertainties and the natural hesitancy of tramp owners to place orders. There is a reference to the turn-round of shipping and the recent improvement in turn-round is attributed to the smaller volume of trade. The report gives details of the representations made regarding taxation and reiterates the warning that the merchant fleet will continue to diminish while taxation prevents the retention of sufficient of the industry's earnings to finance replacement. Flag discrimination, with its adverse effect on world trade, it is stated, is on the increase, and the report goes on to record the developments with regard to oil pollution and the present state of the German and Japanese fleets.

Inadequate Dock Facilities

IN a speech at the annual luncheon of the Southern Section of the Institute of Transport at Southampton on Saturday last, Mr. C. T. Brunner, the president of the Institute, discussed dock facilities at British ports. Saying that Britain's whole existence was bound up with ships and the sea, Mr. Brunner maintained that both our export and carrying trade were being handicapped by out-of-date dock facilities. Demand for shipping space had stimulated the renewal of the merchant fleets and, consequently, shipbuilding had suffered less from post-war restrictions on capital expenditure than other sectors of the economy, including roads and railways. Mr. Brunner went on to suggest that there had been no loss in efficiency in the operation of British shipping but existing port facilities were a brake on higher productivity: out-of-date handling equipment delayed the turn-round of ships, a state of affairs which was often aggravated by over-age docks. Lack of facilities for dry-docking retarded repairs, Mr. Brunner commented, and he went on to call attention to the reluctance of dock labour to employ mechanical handling equipment. This must be remedied, for delays in turn-round not only slowed down our export trade but caused trade to be diverted to more efficient ports. The president then spoke of the economies effected by the use of larger and faster cargo ships but pointed out that such economies would be wasted if suitable docks and jetties were not available. To maintain its supremacy, our efficient merchant fleet, supported as it was by an efficient shipbuilding industry, required shore installations to be of a similar high standard. Mr. Brunner emphasised that the withholding of any capital expenditure necessary to achieve this purpose would be folly.

Institution of Mechanical Engineers Awards

AT the meeting of the Institution of Mechanical Engineers on Friday last, February 20th, the following awards were made for papers presented to the Institution during 1952: the George Stephenson Prize to the late Mr. W. S. Graff-Baker for his paper "Considerations on Bogie Design, with Particular Reference to Electric Railways"; the Dugald Clerk Prize to Mr. D. Downes and Mr. R. W. Wheeler for their paper on "Recent Developments in Knock Research"; the Water Arbitration Prize to Mr. A. E. Johnson for his paper on "Creep Under Complex Stress Systems at Elevated Temperatures"; the Starley Premium to Mr. D. Bastow, for his paper on "Independent Rear Suspension"; Herbert Akroyd Stuart Prizes to Mr. J. Lamb, for his paper on "Explosions in Enclosed Crank-cases of Reciprocating Engines" and Mr. J. R. P. Smith, for his paper on "Use of Heavy Fuels for Medium-sized Marine and Stationary Diesel Engines"; the Thomas Lowe Gray Prize to Mr. A. Holmes Fletcher, for his paper on "The Marine Gas-Turbine from the Viewpoint of an Aeronautical Engineer"; the T. Bernard Hall Prize to Mr. B. Grinsted, for his paper "Nodal Pattern Analysis"; the Engineering Applied to Agriculture Award to Mr. G. A. Wauchope and Mr. H. P. Humphreys, for their paper on "The Design of a Large Pumping Installation for Low and Medium Heads"; the Joseph Whitworth Prize to Mr. S. V. Chung and Professor H. W. Swift for their paper on "Cup-drawing From a Flat Blank, Part I, Experimental Investigation, Part II Analytical Investigation"; the Ludwig Mond Prize to Dr. C. N. Davies for his paper on "The Separation of Airborne Dust and Particles."

British Inland Waterways

A PAPER entitled "British Inland Waterways, To-day and To-morrow" was read before the Royal Society of Arts on Wednesday of last week by Mr. Robert Aickman. Mr. Aickman, who is a vice-president of the Inland Waterways Association, said that Britain's industrial greatness was founded upon canal transport, but that since the coming of the railways there had never ceased to be trouble for the canals. For at least a hundred years, Mr. Aickman continued, inland waterways had tended to be Britain's forgotten industry, though there had been, of course, some important and distinguished exceptions. In general, the paper claimed, it had been deemed injudicious to risk the opposition which large abandonment proposals would undoubtedly have aroused, and preferable to proceed by "simply lying as low as possible" about the whole subject, and doing everything to discourage traffic, in particular by neglecting the statutory obligation of good maintenance. What was wanted, Mr. Aickman asserted, was a determination to maintain all our navigable rivers and canals at least as well as we maintained our roads, and equally, as a matter of course, a resolve to let slip no opportunity to derive advantage from them. Mr. Aickman went on to put forward his views on the beauty of this country's inland waterways, their suitability for pleasure traffic, and their possible use to improve water supply. He concluded by advocating the need for a National Waterways Board, commenting that the first essential was a firm decision that no more navigable waterways should be abandoned or allowed to become derelict. Following such a decision, Mr. Aickman added, everything possible should be done to stimulate all the uses of rivers and canals.

Work Study Training in Bristol

ON Friday last, February 20th, the Engineering and Allied Employers' West of England Association opened a department of work study at Brunel House, Bristol. Its aim is to assist the efforts of the Association's member-firms to achieve greater efficiency and higher productivity. The new department is beginning its work by organising training courses in work study for those responsible for the planning of manufacturing methods and the fixing of piecework rates to give them an opportunity to become fully informed of the latest techniques of motion study, time study, job evaluation, and incentives. It is stated that thorough training and practice in time study will be given to those who need it, and, as many firms in the area are engaged in jobbing and small batch production, attention will be directed to methods of compiling standard data from which operation times can be predetermined. The first full training course will begin on March 9th, and will last for eight weeks. The first four weeks will be spent in full-time instruction and practice at Brunel House, after which the students will return to their respective factories to put into practice what they have learned. During that time they will be visited by members of the teaching staff, who will give help and guidance. The final two weeks of the course will be spent at Brunel House to consolidate the training. It is proposed to hold four such courses during the current year, the object being to give practical help to the students in meeting the day-to-day problems with which they have to contend in their own factories.

Report on Inspection in Industry

THE report of the specialist team on inspection methods in industry, which visited the United States in 1951, under the leadership of Mr. L. Sollis, has now been published. The team reports that although the best British practice in inspection was not inferior to the best in the United States, there was in that country a new and broader conception of quality control. An outline of the principles and practices approved in both countries is given by the team, together with the more striking features of trends observed in America. The recommendations based on the team's findings are divided into two parts. In one set of recommendations of a general character there are suggestions which would require group or national action to apply; and the other recommendations give steps which individual firms could take in adopting the most modern techniques. Amongst the recommendations of a general character is one strongly urging that a technical qualification should be established in inspection and that statistical engineering should be taught in all production engineering courses. Government Departments, nationalised industries and large organisations, it is considered, might well take a lead in adopting sampling inspection where possible and integrating their own inspection procedure with that of their suppliers. In the second group of recommendations to firms it is considered that managements should clearly define the standard of quality it is desired to attain and that this should be related to the selling price of the product. An inspection department should have such a status in an organisation that it should command respect and co-operation and have the full support of the management. It is further suggested that inspection should have the same careful attention from a management with regard to equipment and facilities as is usually given to production departments.

Water Power in the Italian Alps

No. III—(*Continued from page 269, February 20th*)

THE EDISON GROUP

This survey of hydro-electric development in Northern Italy continues with a description of some of the activities and hydro-electric schemes of the largest Italian electricity undertaking—the Edison group of companies. The Edison Company's most recent scheme on the Noce River is first described.

THE Societa Edison, which is the founder member of the Edison Group of companies was established in 1882, with the title of "Comitato per le Applicozioni dell' Elletricita, sistema Edison, in Italia" (Committee for the Applications of Electricity, Edison system, in Italy). The early history of the firm is given in a volume which it has published in English, entitled "The Edison Group," in which a description is given of the power station at S. Radegonda, Milan, which was opened for the production and public distribution of electric power in 1883. The machines were designed and manufactured by Thomas A. Edison himself, it is stated, and the station was the second of its kind in the world, the first being Edison's Pearl Street Station in New York. Since that time the company has been a pioneer in several aspects of electrical development, until now the various member firms of the group form the largest concern in Italy for the generation and distribution of electric power, as well as participating in various other industries, such as the production of town's gas and the chemical, metallurgical, mechanical and electro-mechanical manufacturing industries. At the end of 1951 the Group's generating stations had a total installed capacity of 2224MW and were producing some 6524 million kWh annually. It may be mentioned that the successful start made with the S. Radegonda power station was followed in 1898 by the completion of the Paderno sull' Adda hydro-electric power station, which was the largest hydro-electric power station in Europe at that time. It was of 10MW installed capacity and was connected to Milan by a three-phase, 14kV transmission line, which was then considered very advanced.

In the first of a series of articles entitled "Italian Industries," which was published in THE ENGINEER of April 20, 1906, a correspondent describes this event in the following manner: "Ten years ago the company decided to make one of the most colossal experiments as yet tried, and to transmit from its new hydraulic station of Paderno to Milan—a distance of 36km—14,000 h.p. by the employment of current at 14,000V. The absolute success of the venture is now past history. In 1896, however, many great engineers shook their heads and doubted. The Paderno line marked a revolution in the science of electric transmission, it introduced the employment of metallic supports now in such general use. Theory was strongly against them at the time, on the ground that it would be impossible to ensure complete isolation, and the head engineer of the company, Signor Semenza—to whose personal courtesy I am almost entirely indebted for this information—has described to me the moment of intense emotion when he stood with his hand raised ready to switch on for the first time the current of 14,000V. We are speaking of 1899. Seven short years have passed since then, but events have moved quickly and to-day they switch on 40,000V on the selfsame line without a thought of possible damage." An illustration in our correspondent's article shows that a typical tower of this line was about 11½m high, being nearly 2m in width and consisting structurally of four "N" braced panels, one above the other, with brackets above the top one to carry the insulators and the cables.

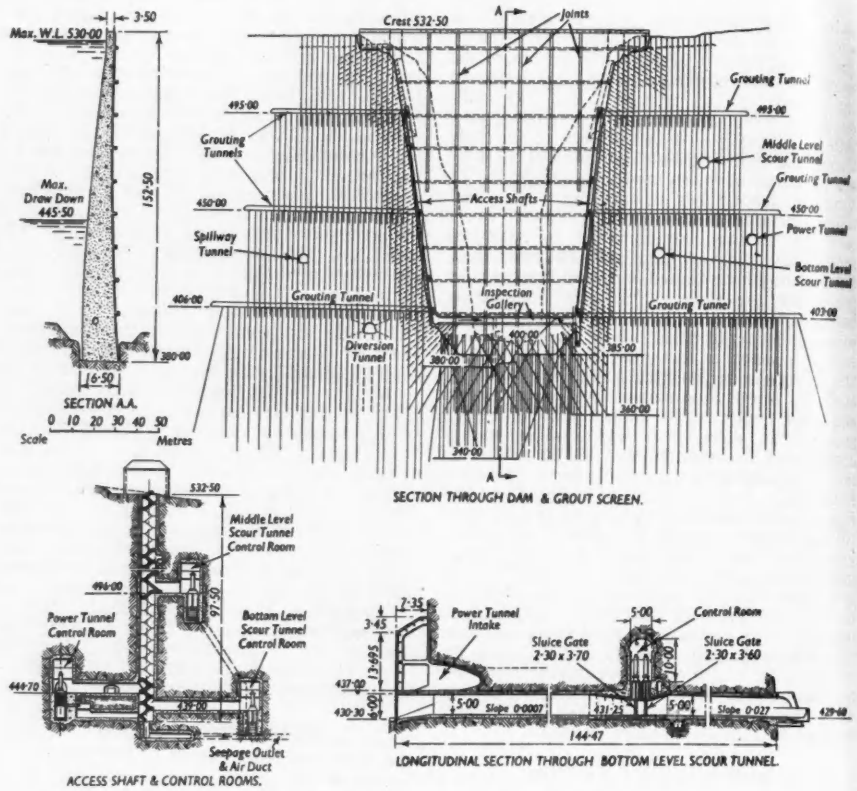


Fig. 13—Cross Section and Grout Screen for S. Giustina Dam

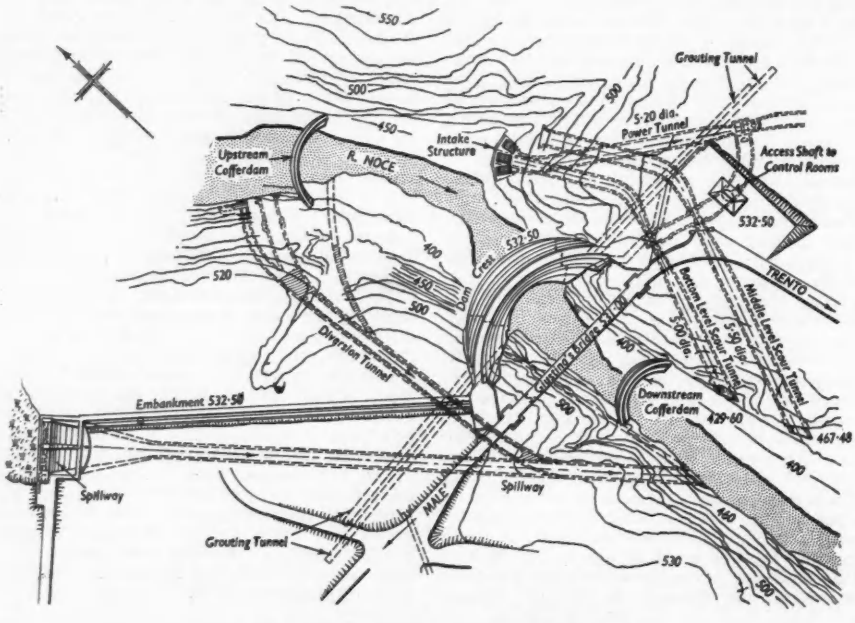


Fig. 12—S. Giustina Dam and Diversion Tunnels

The accompanying table gives the leading data for the scheme,

The S. Giustina Development

Catchment area, square kilometres	1,050
Gross storage, $m^3 \times 10^6$	182·8
Gross storage, acre feet	140,000
Maximum gross head, m.	184·5
Flow, cumecs	66
Installed capacity, MW	103·5
Annual output, kWh × 10^6	300
Winter output, kWh × 10^6	161

which comprises a high arch dam, plugging a narrow, precipitous gorge of the kind so familiar in the schemes of the eastern Alps,

and forming a seasonal reservoir as well as developing a considerable head. A head race tunnel leads under the left bank to an underground power station at Taio, 2km away, and from there a tail-race tunnel, 2km long, leads the diverted water back into the Noce.

The dam is shown, together with the appurtenant diversion tunnels, cofferdams, and so on, in Figs. 12 and 13. As may be observed, the arch is of only 16·5m thickness at the base and the total height of the dam is 152·5m. The photographs reproduced in Figs. 14 and 15 give perhaps a better idea of the steepness of the gorge at Giustina, and of the daring lines of the structure itself. The dam at Tignes (France), which has now been completed, is taller

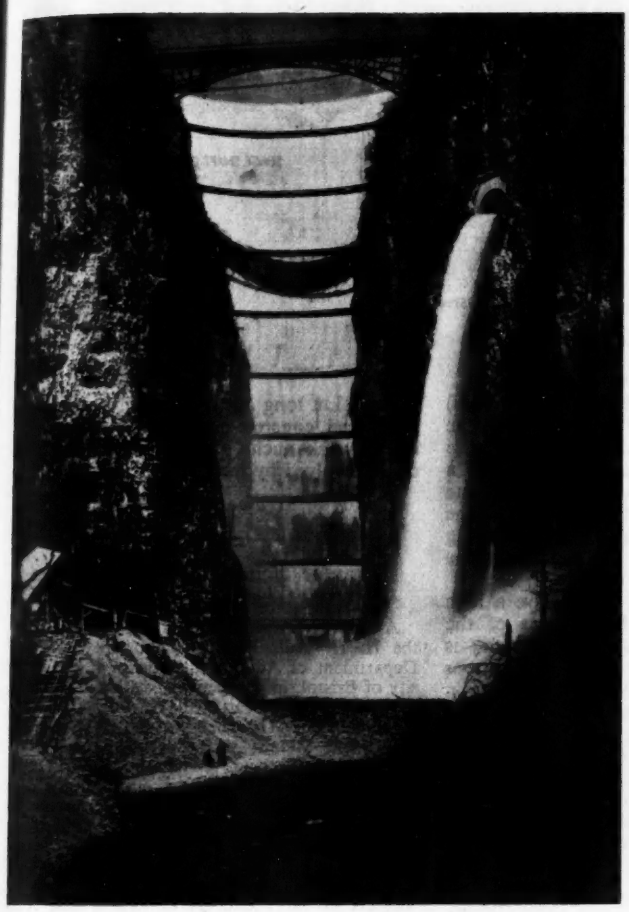


Fig. 14—S. Giustina Dam from Downstream

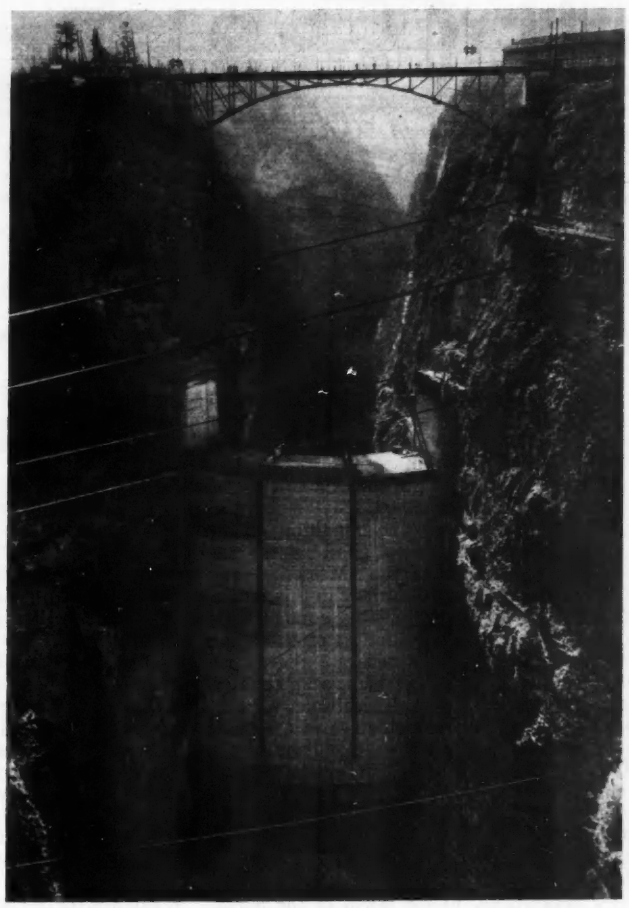


Fig. 15—S. Giustina Dam Under Construction—November, 1948

than Santa Giustina dam (590ft against 499ft) and of larger radius, and a comparison of the two cross sections is not without interest. (THE ENGINEER, December 21, 1951.)

The dam was built in blocks, each 13m long and separated by joints 1·9m wide, which were plugged after sufficient time had elapsed for the concrete to mature. Construction generally was devised to ensure the highest possible quality and the precautions in concrete mixing and so on followed along the lines which are generally adopted for an important structure of this magnitude. The work was carried out by the Societa Edison's own construction section, to the design of the company's chief civil engineer. The concrete contained four grades of aggregates, with 250kg of cement per cubic metre in the lower part and 300kg in the upper part. Extensive grouting was carried out to ensure adequate impermeability of the surrounding rock and Fig. 13 shows the network of grout tubes and the grouting tunnels which were constructed. The total volume of concrete in the dam is about 120,000 cubic metres.

It will be seen from Fig. 12 that the various tunnelling works at the dam site consisted of (*a*) a diversion tunnel under the right bank, which was plugged on completion of the dam, as indicated by the shading ; (*b*) an intake for the power tunnel under the left bank, incorporating also an intake for the scour tunnel for emptying the bottom of the reservoir ; (*c*) a second scour tunnel on the left bank for discharging the middle levels of the reservoir ; (*d*) a spillway tunnel on the right bank with a spillway at the top reservoir level. Thus, emptying of the reservoir is provided for at three levels. The spillway consists of two sluice gates, each 9m by 4·5m in size, at the inlet of a steeply sloping tunnel, which leads into the downstream end of the diversion tunnel. The intermediate scour tunnel has two gates in series, a guard gate and a control gate of 2·8m by 4·3m and 2·8m by 4·2m, respectively, operated by an oil servo-motor ; the outlet tunnel downstream of the gates is 172m long and the maximum head on the gates is 58m. The bottom scour tunnel also has two gates in series measuring 2·5m by 3·7m and 2·3m by 3·6m, respectively, and operated by pressure oil servo-motor. In this case the gates operate under a head of 97m ; the tunnel is 145m long. The various control gates in the left bank tunnel intakes are controlled from underground control rooms, the access shaft to which may be seen in Figs. 12 and 13. The total capacity of the three discharge openings is 1000 cumecs. The power tunnel is controlled by an automatic gate 2·7m by 4m in size.

TAIO POWER STATION

The power tunnel from the dam is of circular cross section, 5·2m in diameter ; it is 2052m long and was designed for a maximum flow of 66 cumecs. The maximum head on the tunnel is 90m at the intake and 107m near the penstock. The surge chambers, penstock tunnel and power station are illustrated in Fig. 16. It will be seen that a single steel penstock, which has a diameter varying between 3·7m and 3·5m, is supported freely in a shaft. There is a vertical surge shaft 102m high, close to the head of the penstock, with a spiral expansion chamber communicating with it, as shown in the diagram. Downstream of the power station there is a tail-race tunnel 1217m long, which is usually under a small head, and an expansion chamber has been excavated just below the sluice gates in the power station tail-race. The form of this chamber may be observed from the plan, the upper end of the chamber forming an emergency outlet for the penstock shaft.

Access to the power station is given by a steeply sloping road, nearly 2km in length, leading down from the Trento-Male highway to the portal of the horizontal access tunnel, which is 325m long. There are three vertical axis Francis turbo-alternator sets, each of 41MVA, installed in the power station. The transformers and the switching station are built at ground level above the power station. A vertical shaft 160m deep carries cables up to the transformers, these cables being at the generated voltage of 10kV. There are four transformers,

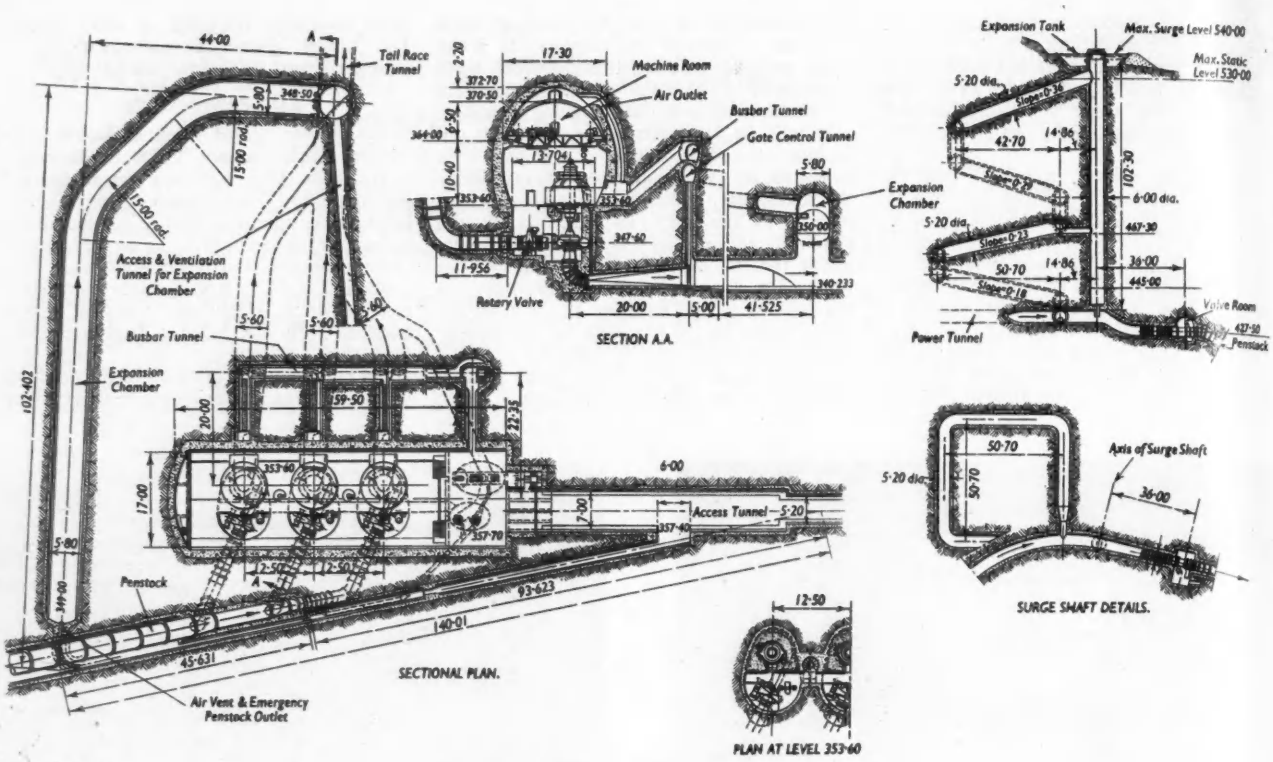


Fig. 16—Taio Power Station and Surge Shaft

each of 70MVA capacity, with voltage ratios of 10/150/240kV ; eight 240kV and four 150kV transmission lines depart from the transformer substation.

A general idea of the construction of the power station and its layout may be obtained from the diagrams. The condition of the rock (marl) was not so good as for the power stations of Santa Massenza and Soverzene, described elsewhere in this article, and the strongest permissible configuration was adopted with an elliptical cross section in elevation and three separate egg-shaped excavations in the lower plan, each containing a turbine with its spherical inlet valve.

This project forms one stage in a scheme for the comprehensive development of the Noce and its tributaries. It will be recalled that a small part of the Noce's catchment is to be diverted southwards to supply the Santa Massenza power station of the Sarca-Molveno project, as described in Part II. The catchment now under consideration lies immediately to the north of the Sarca-Molveno catchment. Two power stations—Malgamare and Cogolo, of 12MW and 94MW installed capacity, respectively, are in operation in the upper part of the catchment, generating a total of about 173 million kWh annually ; the part from the tail-race of Cogolo down to S. Giustina reservoir, remains to be developed and a system of catchwater aqueducts feeding three proposed power stations with a total installed capacity of 121MW and an estimated annual production of 506 million kWh has been designed.

The two existing power stations of Malgamare and Cogolo are supplied from the seasonal reservoir of Careser, which, in its turn, is supplied from glacial streams. Malgamare power station is about 2000m above sea level and is automatic (remote controlled from Cogolo). The Careser reservoir is at an altitude of 2550m. The gravity dam forming this reservoir was constructed between 1930 and 1934. The reservoir has a capacity of 13,000 acre feet. A second reservoir (Pian Palu) has recently been built to regulate the supply to the Cogolo station ; it is at an altitude of nearly 2000m at the site of a former glacial lake, which had become completely silted. The capacity of the reservoir has been increased by excavating this material with jets of water to give nearly 11,000 acre feet of storage.

The reservoirs on this system give a high degree of regulation. The output of the Mezzocorona power station, which is immediately downstream of the Taio power station, has been increased to 211 million kWh annually, an increase of 41 million kWh in the winter half-year, since S. Giustina reservoir has been in operation. Mezzocorona is the last existing power station of the Noce series described above ; it has an installed capacity of 50MW. In Fig. 16 the tail-race tunnel of the Taio power station is shown leading into the Mollaro reservoir ; this reservoir, in fact, provides weekly regulation for the Mezzocorona power station. Another power station immediately downstream of it, Grumo, is planned, with an output of 45,000,000 kWh. The total production of power from the Noce, with all the eight power stations mentioned above in operation, will be about 1225 million kWh annually ; at present this figure is nearly 700 million kWh.

Apart from the power stations along the course of the Noce mentioned above in the Adige basin, the Edison Company owns two power stations, at Pozzolago on the Avisio and Prati on the Vizze (11MW and 24MW, respectively), and the Group participates in the ownership of two modern run-of-river developments on the Adige itself, at Bussolengo (45MW) and Chievo (30MW). The two power stations are operated by the Societa Idroeletrica Medio Adige, which is owned jointly by the Edison Group, by the S.A.D.E., and by the Selt-Valdarno. The yearly output of the two stations is about 485 million kWh. The Bussolengo power station has a head race canal 31km long and includes an impressive reinforced concrete aqueduct bridge ; the intake works include desilting channels of a design evolved by the Edison Company.

(To be continued)

Summer School and Conference at Bristol

A SHORT summer school to be conducted by the H. H. Wills Physical Laboratory and the Department of Adult Education of the University of Bristol, in co-operation with the Institute of Physics, this year, will be followed by a conference on " The Theory of the Plastic Deformation of Metals, with Special Reference to Creep and to Fatigue." The school will be held from July 13th to 16th next, in Bristol. It is announced that the provisional programme of the course which will precede the conference includes lectures by Professor N. F. Mott, Dr. A. J. Forty and Dr. F. C. Frank. The course is similar in conception to those held on similar subjects in the University of Bristol and it is intended mainly for research students at universities and for members of the staffs of Government and industrial laboratories. The particular object of this course is to see to what extent the observed phenomena can be explained in terms of present theories, and to guide future work.

We are informed that the fee for the summer school, which will be on July 13th and 14th, is £1 10s. ; but there will be no fee for the conference. Further particulars and forms of application, to be returned before May 31st, can be obtained either from the Director of the Department of Adult Education, The University, Bristol, 8, or from the Secretary of the Institute of Physics, 47, Belgrave Square, London, S.W.1.

FILM ON MANUFACTURE OF RADIO VALVES AND TELEVISION TUBES.—For the benefit of radio retailers and service engineers, Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, has produced a sound film " It's a Good Sign," describing the manufacture of radio valves and television tubes. Every important stage in production is dealt with, from the making of the glass, fine wire and components, to the assembly, sealing, pumping and testing. The film brings out the importance of automatic machinery in certain processes and of human skill, which still remains paramount in others, such as testing and inspection.

The Proton Synchrotron at Birmingham University

No. II—(*Concluded from page 274, February 20th*)

A new particle accelerator, known as a proton synchrotron, for nuclear physics research, is nearing completion at Birmingham University, under the direction of Professor P. B. Moon. It may be recalled that the project was originated by Professor M. L. Oliphant with the financial backing of the Department of Scientific and Industrial Research. In the following description we give an outline of the design and construction of the proton synchrotron : most of this work was carried out by members of the University staff.

Pole-Pieces

THE exact profile for the pole-pieces was determined by the electrolytic tank method which gave the required information about the flux density distribution across the air gap and about the fringing and leakage fluxes. Both top and bottom pole-pieces were built up of ¼in, 0·08 per cent carbon steel laminations. Before blanking, the hot rolled strip was pickled, cold rolled to the correct thickness and stack annealed. Circular form was given to the pole-pieces by including " wedge " plates in the build-up, the " wedges " consisting, in fact, of a stepped stack of ¼in plates (¼, ½, ¾ and full width), spot-welded together to give the required taper. Twenty-two full plates were inserted between each wedge assembly.

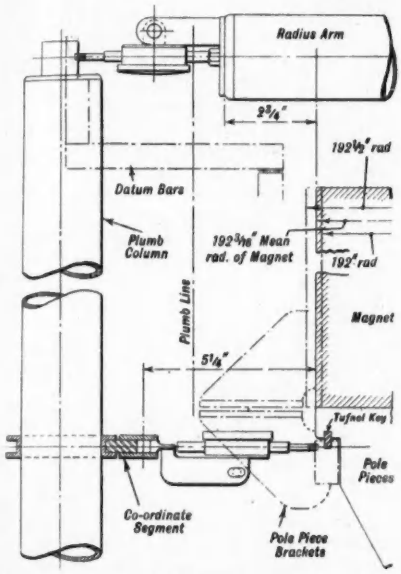


Fig. 9—Setting Up of "Circumferator" Clock Gauges

To ensure uniformity in the air gap the permissible deviation from the plan dimensions (178·5in dia.) of the pole-piece assembly was limited to ±0·050in radially. Accordingly, allowing for all uncertainties introduced by temperature effects and other random errors, a working tolerance of ±0·025in on the radius was adopted.

These tolerances were achieved with the help of a " circumferator "—a device which was specially developed to provide a datum for all points on the circumference of the pole-piece ring. Essentially the circumferator consists of an accurately profiled segment (Figs. 9 and 10) carried on two plumb columns resting on suitable supports on the magnet : the supports can be adjusted by screws and the columns can be set vertical with the help of a Watts level placed on a machined plane at the bottom of each column.

The co-ordinates of twenty-eight points on the segment (Fig. 10) were calculated so that when the segment was correctly set up, the points would lie on the circumference of a datum circle concentric with the magnet. The twenty-eight holes serving as reference points were jig-bored and fitted with hardened steel pins and bushes.

An impression of the procedure for setting up the circumferator is given in Fig. 9. With the help of a radius arm and clock gauge the tops of each plumb column were set at the desired radius. Then the columns were set vertical, using a Watts level as mentioned previously. This setting ensured that all the datum points on the segment lay on a circle concentric with the magnet, as in Fig. 10. A clock gauge, adapted to register with the co-ordinate segment as in Fig. 9, was then set up to provide the correct radial location for each of the rectangular steel locking bars and, therefore, for the pole-piece.

The steel locking bars and the pole-piece brackets can be seen in Figs. 11 and 12. The studs securing the brackets were end-welded to the magnet yoke by Nelson stud welding equipment, supplied by Crompton Parkinson, Ltd. As shown in Fig. 9, the pole-piece laminations are keyed to the steel locking bars by " Tufnol " strips.

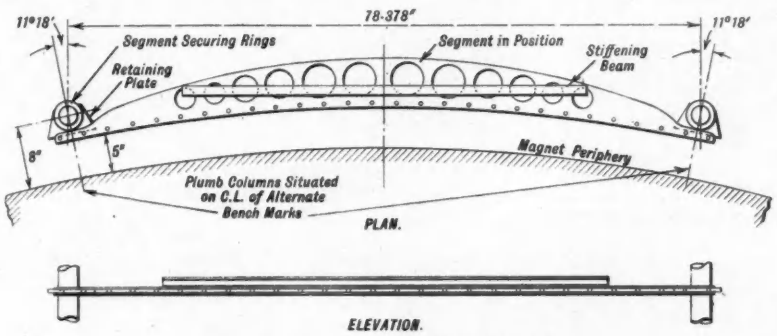
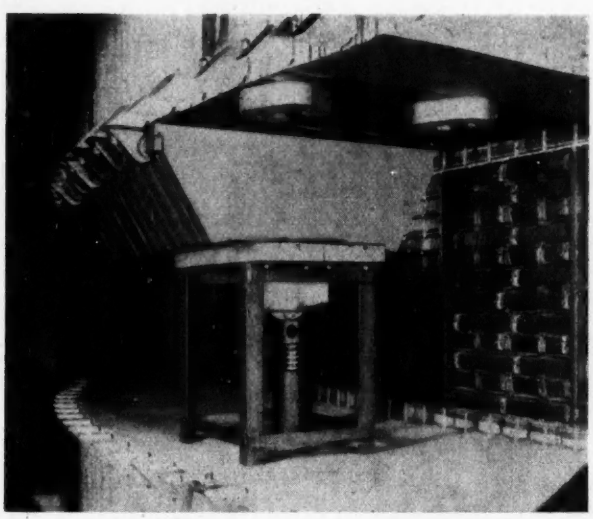
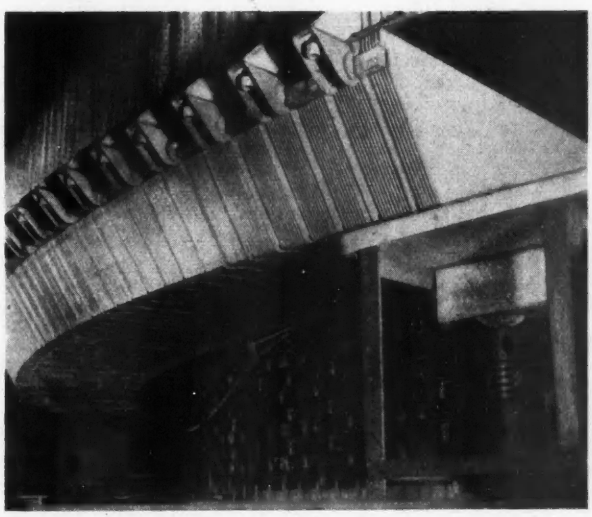


Fig. 10—Assembly of Co-ordinate Segment

The large steel plates for the main body of the magnet were processed from melt to finished machining by Colvilles, Ltd. A number of firms were responsible for the manufacture of the pole-piece laminations : the hot-rolled strip was supplied by Ductile Steels, Ltd.; the pickling, cold rolling and annealing of the strip were carried out by the Stourbridge Rolling Mills, Ltd.; blanking and fabrication of the wedge assemblies





Figs. 11 and 12—Top Pole Piece Ring During Erection

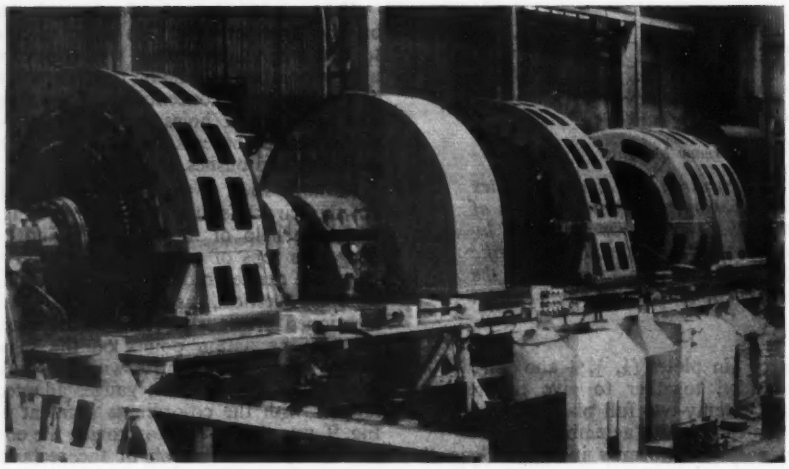


Fig. 13—Motor Generator Set

were done by Turner Brothers (Birmingham), Ltd., who also made the press tools and supplied the pole-piece bracket clamps ; the pole-piece blanks were varnish-insulated by G.B.G., Ltd.

Before leaving the subject of the erection of the magnet, mention should be made of the steps that were taken to anchor the magnet, allowing for expansion to take place but preventing any movement of the structure as a whole. Rows of steel studs were stud-welded radially near the base of the magnet. Each stud was provided with a steel sleeve, allowing a sliding fit so that when the concrete retaining ring (shown in Fig. 2 *ante*) was poured, each portion of the magnet

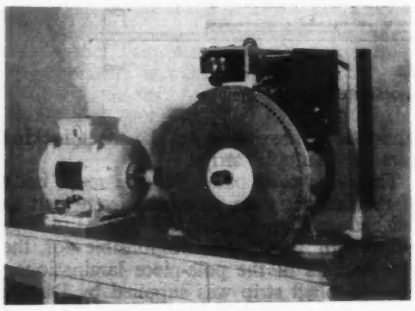


Fig. 14—Sequence Timer

periphery could expand radially ; the necessary cushioning effect was supplied by a bitumenised felt collar previously placed between the cylindrical face of the magnet and the concrete retaining ring. The effectiveness of the device depends on the combined strength of several hundred steel studs, which by analogy, suggested the apt name of " Gulliver's Hairnet " for this novel method of anchorage.

An interesting point about the cooling system is that the motor-driven fan must be designed to operate in a magnetic field of about 800 gauss ; special precautions, therefore, have to be taken to reduce the effects of eddy currents. For this reason the motor is mounted as nearly as possible in the centre of the magnet where the leakage flux is mainly axial. The Keith Blackman fan is of aluminium alloy, and is screened by being mounted in a hollow pedestal of magnetic material. As a precaution against trouble caused by electrolytic action, sleeve bearings are used in preference to ball bearings. A Michell thrust bearing carries the weight of the motor. To prevent eddy currents in the motor frame there is an insulating ring between the shell and the end shields. For the same reason glass sight tubes are introduced in the lubricating system, which is gear pump operated.

The Working Cycle

Excitation of the magnet is by a pair of compound wound d.c. generators connected in parallel and mounted on a common shaft driven by a 1500 h.p., 500 r.p.m., 11kV slip-ring induction motor. A 37-ton flywheel is direct-coupled to the generator shaft and the total energy stored on the rotating parts is 55,000 kilowatt-seconds, to meet the peak load which is thrown on the set once in each ten-second duty-cycle. The motor-generator set was supplied by C. A. Parsons and Co., Ltd.

The magnet duty-cycle is shown in Fig. 15 from which it will be seen that, at the start of the cycle, the generator voltage is at its maximum value of about 1·1kV. From the same point the magnet current rises more or less linearly for one second, while the particles are being accelerated. To de-energise the magnet, the generator voltage is reversed, bringing the current to zero as rapidly as possible after reaching its maximum value of 12,500A. Reversal of the voltage is effected by reversing the field of the generator pilot exciter about 0·5 second after the start of the cycle ; owing to the time constants of the machines the main generator voltage is still about 600V at the end of one second. At 1·5 seconds the pilot exciter field is again reversed to counteract the negative overshoot in the voltage curve

Just under five seconds after the start of the duty-cycle the pilot exciter voltage is made positive and the generator voltage begins to increase, taking five seconds to reach its maximum value of 1·1kV, ready for the next operational cycle.

Each cycle is initiated from the radio-frequency side of the synchrotron by a trigger pulse supplied from the r.f. generator to a thyratron, which fires a " BK22 " glass-bulb ignitron connected between the generators and the magnet.

The firing of the ignitron is reproducible to 1 microsecond, which is sufficiently precise for initiating the cycle, but the " BK22 " ignitron can only handle currents rising to 1000A. To protect against overload, therefore, it is " shorted " by a contactor switch which is timed to close when the magnet current has reached 300A, whereupon the ignitron is quenched. The switch consists of nine contactors, each of 600A continuous rating, connected in parallel and arranged in three banks of three.

Briefly, therefore, this system of switching makes use of the timing accuracy (1 microsecond) associated with the ignitron firing and the necessary protection afforded by the slower-moving contactor. The pull-in coil of the main switch is energised by a separate thyratron which is also energised from the r.f. generator. The pull-in coil, which is energised just before the ignitron, takes 150 milliseconds to build up sufficient current to start movement of the contactor, which then requires 50 milliseconds to complete its travel. On the main switch there is an additional contact which is in series with the igniter of the ignitron and which is not closed until the main switch is in motion. This safeguard prevents the damage that would result if the operation of the ignitron failed to be backed up by closure of the main switch.

After the cycle has been initiated by the timing arrangement described above the remaining four switching operations in the cycle are controlled automatically by a subsidiary sequence timer involving a motor-driven timing-disc, star wheel and cam (Fig. 14).

The generating set and the associated control gear are installed separately from the synchrotron, in a machine room overlooked by a gallery, the general arrangement of the plant being shown in Fig. 16. A photograph of the main set on the test bed at the makers' works (C. A. Parsons and Co., Ltd.), is reproduced in Fig. 13.

It will be seen from the plan of the machine

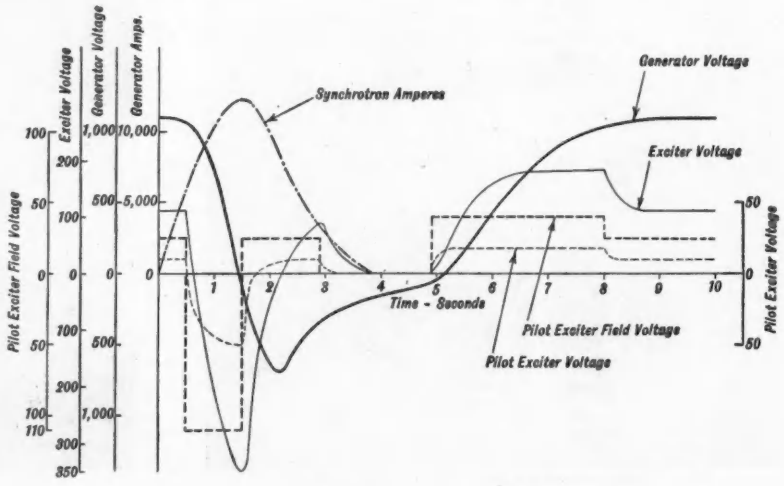


Fig. 15—Duty Cycle

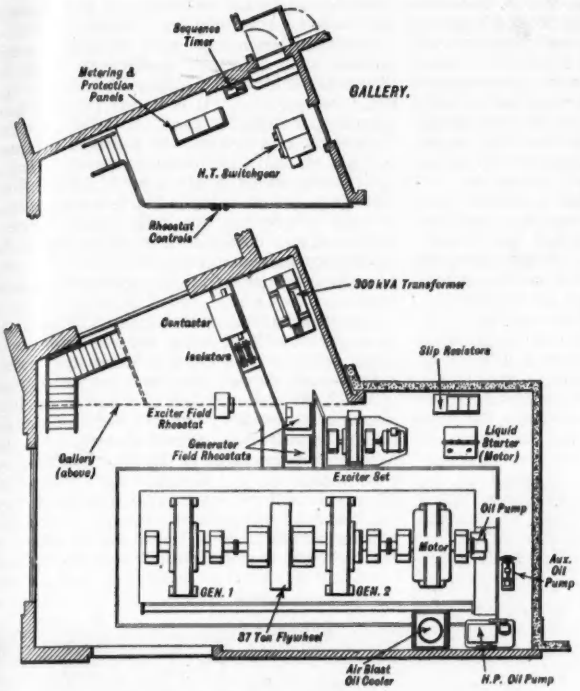


Fig. 16—Plan of Generator Room

room that there are three oil pumps to ensure continuity of operation by the forced lubrication system. For normal supplies there is a gear pump driven from the main shaft. There is a separate motor-driven high-pressure oil pump for starting and slowing down. Finally, as an auxiliary, there is a hand-operated ram pump which is capable of raising the weight of the rotating plant off the bearings.

A switchboard incorporating the necessary metering and protection panels is installed in the gallery. Since the main contactors must remain closed while the magnet is excited (because of the high reactance of the circuit) two field circuit breakers are provided to offer protection in the event of the magnet current running away. On the panel above the field circuit breakers there are two out-of-balance generator trips.

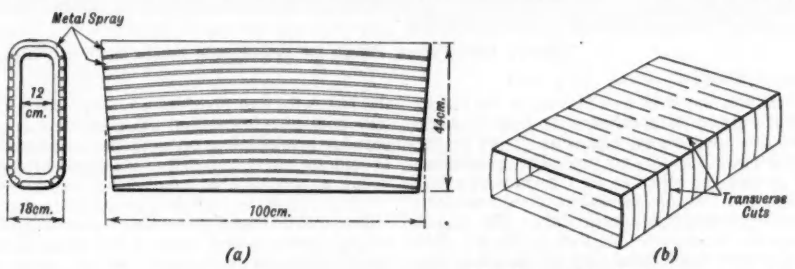
In order that tripping need not be resorted to except in the event of a serious fault, an earth leakage milliameter and alarm lamps are included in the protective panel.

Vacuum Chamber and Accelerating Electrode

Details of the vacuum and radio-frequency systems of the synchrotron have been or will be discussed in full elsewhere. The following brief account is included in order to complete the description of general engineering details.

The vacuum system† consists of sixty straight sections of electrical porcelain arranged to form a hollow ring-shaped chamber or "doughnut." The joints between sections are sealed by gaskets consisting of rubber rings moulded on either side of brass plates. The required vacuum, about 10^{-6} mm of mercury, is achieved by five 16in oil diffusion pumps disposed around the ring and feeding into a common backing line. A stainless-steel manifold connects each pump with six of the porcelain sections, through a pair of ports on each section.

To prevent the accumulation of charges on the walls of the vacuum tube, it must be lined with a conducting material, which must not be so thick that eddy currents of a troublesome magnitude will be set up. In the absence of a lining electrostatic fields sufficient to force the proton beam off the required orbit would soon eventuate. In preference to the arrangement shown at (*b*) Fig. 17 the lining is formed by firing on to each porcelain a thin uniform coating of platinum, which is carried over on to the ground ends. Connection between adjacent sections is made by means of spring clips attached to the brass plates which carry the rubber gaskets. The sixty sections are coated and connected in such a way as to form two groups subtending angles of 264 deg. and 96 deg. respectively. The former is earthed and the latter is maintained at an r.f. potential of 240V (r.m.s.). The accelerating electric field is developed across the gaps between he two groups of sections.



Experimental "Inconal" liner to remove wall charges

Fig. 17—A Straight Section of the Vacuum Chamber

In principle, the shorter platinum tube alone could form the accelerating electrode, or "cee." However, at the highest radio-frequency (10 Mc/s) very large capacitive currents are caused by the close proximity of the "cee" and magnet pole faces. These currents must not be carried by the platinum, so a "cee" in the form of a low-resistance silver coating is fired on to the outside surface of the porcelains forming the short tube. The silver is laminated to reduce eddy currents due to the changing magnetic field, and consists of 1in wide strips separated by $\frac{1}{8}$in ((*a*) Fig. 17). Once again, the strips on adjacent sections are joined by spring clips attached to the gaskets. The connections through to the platinum at the "cee" ends are made by carrying the silver over the ground porcelain-ends to meet the platinum.

The ground return of the capacitive currents is made through strips of copper foil attached to the pole faces. These strips are cemented to thin "Tufnol" sheet, which is held to the laminated pole face by small screws.

Acknowledgment

The general design of the proton synchrotron was the responsibility of Professor M. L. Oliphant and the late Dr. J. S. Gooden. A number of individuals collaborated in the project. Mr. H. H. Taylour carried out the engineering design of the magnet and, with Dr. R. W. Pohl, who acted as engineering consultant, was responsible for liaison with C. A. Parsons and Co., Ltd., upon technical matters involving the generating plant. The main control panel and protective gear were designed and made by A. Reyrolle and Co., Ltd., in collaboration with Dr. Pohl and Mr. Taylour, who also designed the duty-cycle control. The operation of bringing the generators and magnet into service has been under the care of Dr. J. L. Symonds. Dr. L. Riddiford is responsible for the vacuum system and Dr. L. U. Hibbard for the radio-frequency equipment of the proton-synchrotron.

We acknowledge the facilities that have been freely extended to us, in the preparation of this article, by Professor M. L. Oliphant, Professor P. B. Moon and their collaborators.

† L. Riddiford, "The Vacuum System of the Birmingham Proton Synchrotron," *Journal Sci. Instr.*, Supplement I, page 47 1951).

A Prestressed Concrete Station Roof

The construction of a new roof at Sheffield Victoria Station on the Eastern Region of British Railways is at present in progress, to replace the original roof built during the period 1850-1880. A number of alternative designs for the new covering were given very careful consideration and the design adopted is one which incorporates prestressed concrete beams spanning between the existing walls and carrying over the platforms fully glazed suspended awnings of light construction. The prestressed beams weigh approximately 12½ tons each and are generally at 25ft centres. Their overall length is 87ft 9in, the depth of the section being 1ft 9in at the ends and 3ft 3in at midspan. The concrete is prestressed with 0·276in diameter high tensile steel wire in two sixteen-wire Magnel Blaton straight cables. Sockets are cast into the beam to take the steel suspension rods. The steel framework of the awnings consists of arched ribs, purlins and facia. The arched ribs are 9in by 4in R.S.J.'s about 25ft 6in long over the down platform and about 23ft long over the up platform. All connections, steel to steel, are made by welding. A parcels bridge, spanning the platforms and tracks, divides each awning into lengths of approximately 211ft and 177ft. Each rib is suspended directly below the prestressed beam by four hangers made from 1¼in diameter rods, screwed into the beam sockets. The length of each hanger can be adjusted by a turnbuckle and any movement of the awning due to temperature change is provided for by fork coupling at each end of the rod. The suspension members are protected by non-corrodible sheathing.

When electrification of the lines takes place the overhead electrical equipment will be suspended from certain of the prestressed beams, which have been designed to take the additional load. The principal advantages of the design as adopted are the ease of maintenance generally and the freedom from column supports on the platforms: the latter advantage was also a feature of the previous high-level roof. The design of the new roof was carried out under the supervision of Mr. J. I. Campbell, M.I.C.E., the civil engineer of the Eastern Region of British Railways, and the contract has been let to Samuel Butler and Co., Ltd., Stanningley, Nr. Leeds.

Movement of Shipping.—The returns of shipping entering and clearing United Kingdom ports showed that the net tonnage of vessels entering increased by 3·3 million tons, and the clearances increased by 3·6 million tons over the returns for 1951, the corresponding totals being 81,596,000 tons and 82,108,000 tons respectively.

Work at the National Institute of Agricultural Engineering*

By W. H. CASHMORE, N.D.A., M.I.B.A.E.†

The National Institute of Agricultural Engineering is now established in permanent headquarters at Wrest Park, Silsoe, Bedfordshire. It is an organisation which has developed from the Institute of Agricultural Engineering, set up, in 1924, as a department of the University of Oxford. In his paper, Mr. Cashmore reviews some of the research and development work now in progress at Wrest Park.

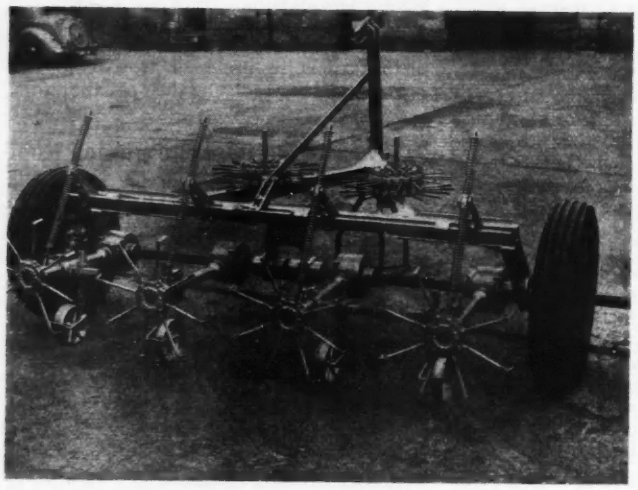
WHEN the National Institute of Agricultural Engineering began its move to its permanent headquarters in 1947, its terms of reference were defined as being " to assist the mechanisation of agriculture and horticulture." A long-term programme is agreed with the Agricultural Research Council, but there is sufficient flexibility to allow additions and modifications to be made when required by the trends of the work. Requests for items to be included in the programme come from various sources, such as advisory committees of the Ministry of Agriculture, working parties and trade research associations, on all of which the N.I.A.E. is represented. There is close contact with research at the universities, and some of their pilot investigations may be continued in the N.I.A.E. programme. More recently inquiries have been received from various parts of the Dominions and Colonies. In addition to outside requests, the N.I.A.E. itself puts up items for the programme, based on previous investigations, and its contacts through testing and other sources.

The staff responsible for testing is quite separate from that engaged on development and research. Up to eighty tests a year on tractors and implements are carried out at the request of manufacturers. In addition, some " records of trial " of machines, purchased by the Institute, are made to obtain information for internal use; quite often these are imported machines of a kind new to this country. It is the policy of the Institute to evolve, as opportunity offers, standard tests for each class of implement; so far such tests cover tractors, grass and grain driers, hammer mills and fertiliser distributors, and advanced testing techniques are available for ploughs, potato planters, complete potato harvesters, and sugar beet harvesters. Many of the tests for manufacturers are on prototypes or component parts. Sometimes a machine may be submitted several times during its development. The test report enables the entrant's development staff to note progress, and it also contains a number of suggestions for improvement, many of which are incorporated in the final design. In special cases development tests are carried out during which modifications are made in the N.I.A.E. workshop between trial runs in the field. The cost of such work is charged to the firm as an addition to the normal test fees. Standard tests for machines closely associated with soil have not been developed because of the difficulty of assessing soil conditions reliably. Laboratory methods have proved unsatisfactory, but it is hoped that field work being done by the soil physics section will make it possible in future to specify soil properties.

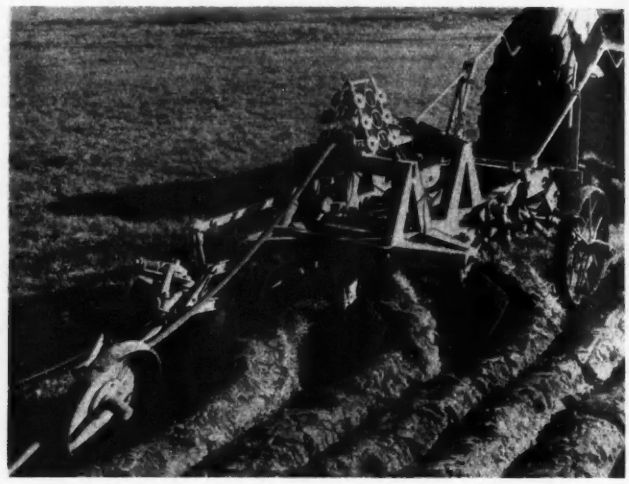
Before development work on equipment for a particular problem is proceeded with, a number of investigations into the problem are carried out. These investigations are carefully planned on statistical lines, and detailed measurements are made of as many variables as possible, so that the results can be applied to other specified conditions. An investigation may indicate a more efficient way of carrying out a farming process by the better use of existing equipment, or the possible need for new or improved equipment. In the case of either of the latter, the data obtained relate the performance to detail of design and provide basic information on which a manufacturer can build the machine or machines needed. Should the prototype of such a machine be submitted for test, the testing department can use this basic information in drawing up a scheme of test. The development of a machine may start as a lash-up in the blacksmith's shop and be modified and rebuilt, as work in the field progresses, and, finally, go to the drawing-office for tidying up. The alternative is to design the machine in the drawing-office initially, and for this procedure it is necessary to have the appropriate basic data. The choice is mainly dependent on the problem; for instance, with implements closely related to the soil, development usually starts as a lash-up because present knowledge about the relationship between soil properties and machine performance is not sufficiently understood. All N.I.A.E. development is closely associated with experimental work so that if it subsequently becomes necessary to modify a machine to meet another set of conditions, there is a sound basis on which to make the changes. For this reason much of the N.I.A.E. development will be helpful in connection with overseas applications. When it is thought desirable in the interests of future manufacture, designs are patented and handled by the National Research Development Corporation.

In the course of development, machines are built in the workshop and brought to a standard which enables a full test to be carried out. No attempt is made to carry the design to the stage of a manufacturer's production model. The Institute is always ready to discuss a development scheme with an interested manufacturer. There is often close co-operation before an investigation is concluded, and, also, ideas for component parts as well as experimental data can assist manufacturers in their own development. In this way the benefits of N.I.A.E. work reach the farmer in the quickest possible time. The Institute designs and builds a good deal of special test equipment varying from simple devices to complicated recording gear in self-contained mobile vehicles. Such equipment speeds up the work, widens its scope, and reduces the personnel required. It is hoped that the more simple gear will be used in the Dominions, Colonies and countries where British machines are used, so that their performance can be linked up with the standard test at the N.I.A.E. Some manufacturers are using N.I.A.E. test equipment for their own testing, but, in the case of the more elaborate and costly devices which cannot be justified by individual firms, the N.I.A.E. is able to make it available to manufacturers for special trials.

Experimental machines are designed and built by the N.I.A.E., to meet the requirements of other research stations, and when the experimental work carried out there reaches a stage at which the manufacturer of a new or modified machine is justified, the N.I.A.E. can advise on the details and general design, using the experience gained during the trial runs with the experimental unit. Contact with farmers on all aspects of the N.I.A.E. work is made through the National Agricultural Advisory Service. A liaison unit stationed at Wrest Park ensures that the N.A.A.S. is in close touch with the work of the N.I.A.E., and provides a channel for a two-way flow of information. The Institute is prepared to give opinions on agricultural engineering inventions, but if, as is often the case, an invention needs a considerable amount of development work spent on it before any progress can be made, the inventor is usually dissatisfied. For obvious reasons, the Institute cannot undertake development work for an inventor unless the idea shows considerable promise and is closely allied to some part of its programme.



Experimental Root Thinner



Modified Three-Furrow Plough for Investigating Forces on Plough Body

Examples of Work in Hand

Investigations.—The work with haymaking machinery is a typical example of N.I.A.E. investigations and was included in the programme because it is one of the main divisions of grass conservation and one which is most wasteful. The losses are primarily due to unfavourable weather, and haymaking machines, and methods of using them, aim at reducing the chances of loss in a bad season. Obviously, a study of haymaking is mainly concerned with the possibility of raising the quality of hay by improved methods or machines. Before the experiment proper could start it was necessary to consider ways and means of making measurements. For instance, to enable the required number of moisture estimations to be taken on the spot, a modified Brown Duvel method was evolved, and a semi-automatic chopper was designed and built to process the material before estimating.

An early part of the work was an investigation into dry matter loss during the " making " process in the field. Experiments which started in 1951 showed that this loss may vary from over

* Institution of British Agricultural Engineers. February 24th. Abstract.

† Director, N.I.A.E.

20 per cent in an immature crop cut in May to over 4 per cent in a fibrous crop cut in July. These losses occur with gentle hand treatment, and the harmful effects of faulty methods or harsh treatment by machinery would give greater losses.

Another part of the investigation was an attempt to correlate loss of moisture from the swath with climatic conditions, so that the results obtained from the main investigation could be interpreted for a range of seasons and for different parts of Britain. The possible effects of new kinds of equipment have to be taken into account, and the investigation covers a pick-up roller crusher of Canadian design, a flail cracker designed and built in Britain, and a swath aerator from New Zealand. Work to date with stem crushers and bruisers indicates that the design of machine has little influence on the results.

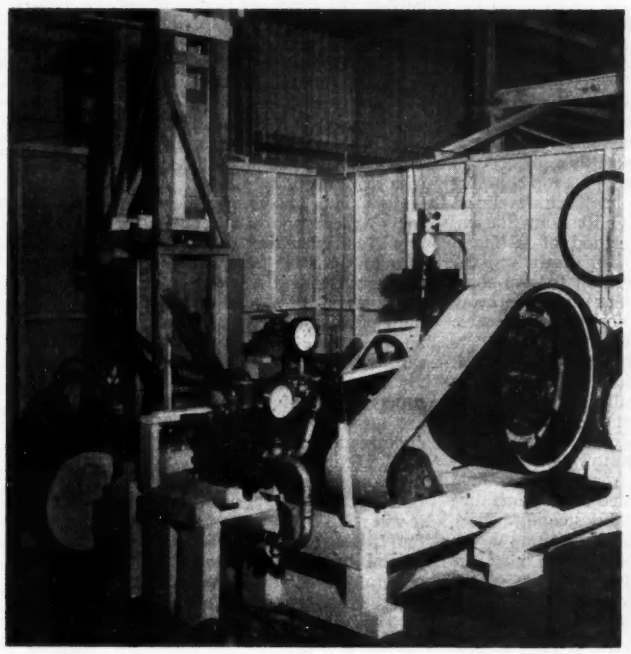
Haymaking by pick-up balers is rapidly increasing in favour, and the crop from field plot, with various treatments in the "making" stage, was baled at moisture contents ranging from 20 to 30 per cent, and bale densities from 10 lb to 13 lb per cubic foot. The bales were stooked in the field, weighed at intervals and stored and left to be examined for quality at a late date. From some of the plots hay was chopped to lengths of about 5in with a pick-up cutter chopper and stored in small experimental Sisalkraft silos, at moisture contents ranging from 20 to 26 per cent. Temperatures were recorded and the chopped hay stored for some months before examination for quality. This was only a pilot experiment with the object of finding one machine for collecting hay dried in the field, and green material for silage. It is an accepted fact that haymaking and silage making are complementary methods of grass conservation, but when both are practised on the small and medium farm, a great strain is placed on the capital invested in equipment unless heavy hand work is employed. The investigation will have to continue for several seasons because, until more is known about the relationship between various mechanisms on the loss of dry matter, the rate of drying in the field and the subsequent feeding value, it is not possible to decide which machines are worthy of further attention, or whether new designs are advisable. At the present time an extensive test of a haymaking machine can do little more than indicate the machine's durability. It is certainly difficult to see how new machines can be designed for a particular set of conditions without the basic information.

Another investigation, into American "down-the-row" root thinners, began as a record of trial on a machine imported from the U.S.A. The investigation into a scheme of test for this class of machine has now developed into an investigation into the spring mechanisation of root crops. The work began on the beet crop and has included close measurements on a number of small plots, linking up performance, measured as the saving in singling time, with such factors as rubbed or natural seed, high or low seed rates. Other measurements include the plant population at varying stages, and the final yield. The plot experiment was followed by a field scale experiment in 1952. Preliminary results indicate the possibility of an appreciable saving of labour without an associated loss of plant population, or regularity in the rows, but considerable skill and field experience with a fair range of adjustments on the machine seem to be essential. Because of the importance of the matter and the fact that manufacture may be arranged in this country, it is hoped that a member of the staff who has worked on this scheme will have an opportunity of visiting the U.S.A., where these machines have made a phenomenal rise in popularity.

The investigation will be extended to other crops, and already it has been tried on a small scale on turnips, parsnips, kale and lettuce. An experimental down-the-row thinner (shown in an accompanying illustration) is being built in the N.I.A.E. workshop, so that the Scottish Testing Station can experiment on root crops grown on the ridge.

Research.—Work on plough design and the effect of tractor wheels on soil structure are examples of N.I.A.E. research. A three-furrow plough has been modified, as illustrated, so that the middle body is completely suspended by a series of wire resistance strain gauge components, which enable the forces acting on the plough body to be recorded, the vertical and horizontal forces being measured. It is thought that deviation of the forces from the mean value will be important because it is the fluctuations in loading which are often considerable and allowance has to be made for them in designing a plough. The main kinds of plough body—general purpose, semi-digger and digger—have been compared at working speeds ranging from ¾ to 5 m.p.h. Preliminary experiments indicate that the semi-digger body has a slightly higher draught than the other two, and that increasing the speed increases the draught of all three kinds, which rises more sharply at the higher speeds by about 25 per cent. This work will provide useful information to plough designers, particularly in connection with mounted ploughs, but it is obviously long term.

In the soil physics section, attempts are being made to measure the mechanical properties of the soil. Apparatus which has been developed includes a torsion shear box to measure shear strength of top soils and an adhesion meter for determining the value of the strength with which soil clings to other materials. Until some of the fundamental principles are understood sound progress cannot be made in developing machines closely related to the soil. Some of the measurements have a bearing on other N.I.A.E. investigations. For instance, if a relationship can be established between the dirt tare of sugar beet and the adhesion of the soil, it should be possible to compare the performance of a beet harvester on one soil with that of another working on a different soil. In connection with the effect of tractor wheels on soil structure, experiments have been made on the change in volume weight of the soil, and penetrometer readings have been made; results indicated that compaction did not occur deeper than 4in, but that quite often the tractor wheel running in the furrow bottom reduced soil drainage, showing that water permeability was an important factor. The work on the latter has been done in collaboration with the soil department of Cambridge University; plots of land surrounded by impervious channels have been irrigated and the run-off collected in the ditches surrounding the plots, the permeability being indicated by the proportion of the applied water which can be collected.



Testing for Tractor Hydraulic Transmission System

Development Work

A recent instance of development in which the N.I.A.E. was asked to assist has been that of a machine to harvest groundnuts. Three different machines, which are being developed for harvesting potatoes, were sent out to Tanganyika in 1952, and operated under a wide range of conditions by N.I.A.E. staff. As a result of these trials and experimental runs with stationary rigs on the site, a new design has been evolved for lifting, removing soil, stripping off and bagging the nuts in one operation. This machine has been built in the N.I.A.E. workshop and was given a trial during November, 1952, on an out-of-season crop of groundnuts grown on irrigated land; it is now being tidied up for the main trial this spring.

Another development which is a long-term one, and which might make a very important contribution to agricultural engineering, is the hydraulic propulsion of a tractor. The principle is that of an engine-driven pump of variable output, supplying oil to hydraulic motors built into tractor wheels. The hydraulic motor is designed so that the wheel is made to revolve round the stationary stub shaft. A single control lever on the pump can give stepless variable speeds forward, or reverse, and the changes can be made without stopping. If the system proves successful it would simplify the design of farm tractors and make it possible to change from two-wheel to four-wheel drive at a relatively small increase in cost. The most important advantage would be that the designer would be free to use the space taken up by the orthodox transmissions. It would revolutionise the design of self-propelled implements, because the engine and pump could be mounted in an easily accessible position and transferred from one machine to another. Before it can be decided whether the design is practicable, a number of details have to be examined, such as the life of the hydraulic motor and the initial cost. Preliminary work with an experimental testing rig—illustrated herewith—has given encouraging results and the work is proceeding.

Work on grain drying serves as an example of how design improvements are brought about. Earlier research work had established two systems for dealing with amounts of grain which do not justify purchase of a standard grain drier—the platform drier and the ventilated drying silo. In each case the main lines of plant layout have been accepted after extensive trials on farms and the N.I.A.E. work on this subject is now mainly concerned with details of equipment, aiming at improved performance. In 1949 three platform driers were placed on farms, and by the 1952 harvest there were some 750 plants in various parts of Britain. As a result of consultations with the N.I.A.E., a platform drier has been installed at the Empire Cotton Research Station at Kampala, Tanganyika, for drying cotton seed and maize; another has been used by the Sudan Government at Juba for drying sorghum and an experimental unit will be operated in Tanganyika in connection with the development of a groundnut harvester, in co-operation with the Overseas Food Corporation. Development work is proceeding on lightweight combustion equipment, which will cover the possible future requirements and be suitable for platform or silo driers. The idea is to produce a unit integral with the main ventilating fan so that it can be delivered to the farm as a single piece of equipment easy to install. The principle of the ventilated silo plant is to pass warm air up through a porous or perforated floor. To improve the performance by reducing the pressure loss across the floor, a number of alternative materials have been tested, including slotted blocks and perforated tiles. For all work on

grain, special equipment has been investigated and developed, including electric hydrometers, moisture meters, and airflow meters for measuring air velocities below 25ft per minute.

Horticulture

Horticulture, like agriculture, is making increasing demands for new machinery and equipment to enable growers to raise the efficiency of their production, Until the horticultural department was set up as part of the N.I.A.E. in 1948, there had been very little official investigation work into horticultural engineering problems in Britain. The horticultural department carries out investigations and research to determine basic principles and data, and also develops machines and equipment, but the testing of horticultural machinery is dealt with by the agricultural testing department. The programme is divided into five main sections—vegetable, glasshouse, fruit, cultivations and more general horticulture. In all this work there is close co-operation with other research stations, the N.A.A.S. Advisory Farms, and the work of other N.I.A.E. departments.

An example of the horticultural work is concerned with spraying. Earlier investigations into the physics of drift spraying had resulted in the development of a low volume sprayer which was studied in co-operation with East Malling Research Station. It was found that the droplet size would need to be smaller and more uniform. Further development work on this subject will be greatly assisted by the use of a drop counting and sizing machine, which has been developed in conjunction with the G.P.O. Research Station.

Although no standard method of testing a spraying machine has yet been drawn up, the N.I.A.E. is already in a position to give some assessment of performance, and various spraying machines have been sent for trial to enable manufacturers to make improvements.

Of the many other problems being tackled, another is mentioned because it illustrates the link-up of programme internally. In an investigation into the steerage of horticultural tractors, a deviation meter has been designed and constructed to measure the extent to which the tracking of a set of tools deviates from a given straight line. The deviation is recorded at the same time as the torque exerted on the steering wheel, and the angular deflection of the steering wheel. These three factors should eventually relate the position of the driver to the accuracy of the operation, such as hoeing. As already mentioned, experimental work has been started on a hydraulic transmission tractor, which, if successful, would be of particular interest to horticulture, and the results of these steering experiments would be incorporated in any experimental tractor built for horticulture. Apart from this possibility, the information, when obtained, will be available for manufacturers of small horticultural tractors.

Scottish Station

The Scottish station at Howden operates the same testing scheme as that at the N.I.A.E. headquarters. Machines manufactured in Scotland are usually tested at Howden, but there is an interchange with Wrest Park, when the requirements of the test make it desirable. Generally, the Scottish station can more easily provide wet conditions, hilly land and rough marginal land. The season in Scotland is also later and sometimes machines are moved up from the south to obtain an extended season. In addition to testing, investigations and experiments form an important part of the programme ; there is a link-up with the main N.I.A.E. programme, and research work on root harvesters, potato harvesters and grass driers, for example, is undertaken under Scottish conditions. The Scottish station has a number of problems of its own, such as the effect of sloping ground on the performance of machines. The investigation into land reclamation and improvement is an example of work carried out in co-operation with economists, botanists and advisory officers of the Scottish colleges.

In addition to working specialised reclamation machines and stump-jump equipment designed for working stony ground, bracken control and eradication are being tried out in two areas representing different kinds of land, one the rolling hills, and the other steep slopes with numerous outcrops of rock. The special machines being compared are a bruiser, a crusher, a breaker and a slasher ; a standard mounted mower has been included for comparison. Another experiment has been arranged to compare the efficiency of high or low cutting with a mower. The results will indicate the possibilities of using a cutter bar in districts having an outcrop of stones. The prevention of the spread of bracken is an equally important matter and is the subject of a further investigation in which trenching, ploughing, rotary cultivation, disc harrows, rotoflail and chemical treatment are being investigated.

Conclusions

The N.I.A.E. policy is not only to improve the standard of farm machinery and equipment, but also its status by co-ordinating the work of research stations, the experience of farmers and the development and experimental side of implement manufacture. The Institute is neither equipped nor expected to show farmers or implement manufacturers how to carry out their own work. Even on the most highly mechanised farms, management and organisation extend far beyond the mere use of machinery. Similarly, the N.I.A.E. aims to assist the manufacturer in his design, development and testing, but, in addition, there are the matters of production, sales and service.

It is absolutely essential that the N.I.A.E. should be in very close touch with the practical side of agricultural engineering. The overall response from manufacturers and farmers could, with advantage, be greater. It is disturbing to find a greater interest in a piece of research from overseas countries than at home. New and improved machines are necessary for British farming and the export trade. In some cases our level is such that we have little to gain from examination of overseas models, and design must proceed on results from experimental work and research. On the other hand, there are cases where improved machines have been made for new methods, but these methods are not properly understood by the farmers, and results are unsatisfactory. As far as the N.I.A.E. is concerned, both the N.I.A.E. reports and the N.A.A.S. information based on them are worthy of more attention. Increased production can be expected from agriculture in the future, but it will not be due to improved equipment alone, but to the combined efforts of plant breeding, animal breeding, soil science, &c., with agricultural engineering. Lack of attention to this fact can easily result in wasted effort.

Steel Rolling Mill for Western Australia

The raw material resources of Western Australia are considerable, but her industrial development has lagged much behind the rest of the Commonwealth. Even at the end of World War II she was still producing more wheat, wool and gold than manufactured goods. Since the war, however, there has been an intense drive towards industrial development. A new industrial centre has been established at Welshpool, near Perth, in a wartime munitions plant, which produces oxides, metal products, fabricated steel and diesel-powered heavy-duty wheeled tractors. Rapid strides have also been made in the development of pyrite deposits for the production of sulphur. More recent developments were the opening up in 1951 of new iron ore deposits at Yampi Sound, on the north-west coast (Lat. 16 deg. S., Long. 124 deg. E.) by Australian Iron and Steel, Ltd., and the agreement with the Anglo-Iranian Oil Company, Ltd., to erect Australia's largest oil refinery at Kwinana, on the shores of Cockburn Sound, immediately south of Fremantle. The latest project is a joint enterprise by the State and private industry, approved by the State Parliament at the end of last year. An agreement has been reached between the State and the Broken Hill Proprietary Co., Ltd.—with which Australian Iron and Steel is associated—under which the company undertakes to construct within five years a steel rolling mill with a capacity of 50,000 tons of steel products per annum at Kwinana, together with a jetty and other facilities. The State, for its part, is to provide electric power, road, rail and fresh water facilities for the mill site, and to dredge a deep-water channel and swinging basin for the steel mill jetty in Cockburn Sound, to provide access for ocean-going ships. A £2,000,000 contract has, in fact, already been signed for the dredging work. The whole project is intended as the first step towards establishing a basic heavy industry in the State of Western Australia.

The new mill, which will adjoin the oil refinery, will involve an expenditure of between £3,000,000 and £4,000,000, and is being specifically designed to meet local requirements. It has been a long-established policy of the Broken Hill Proprietary Company to decentralise secondary industry, and with the opening up of iron ore deposits at Yampi Sound, the possibility was explored of using this ore within the borders of the State. Unfortunately, however, the large reserves of black coal at Collie, in the south-west—estimated to total at least 310 million tons—do not provide good metallurgical coking coal and no economic method has yet been devised for using them in iron and steel production. As part of the agreement the company is " to collaborate with the State in carrying out investigation and research in the use of coal from the Collie coalfields in primary furnaces for the conversion of iron ore into pig iron with the aim of establishing an integrated iron and steel plant within the State." Meanwhile, the raw material for the new mill, in the form of steel billets, will be supplied by the steel works at Newcastle and Port Kembla and the large vessels specially built by the company for the carriage of iron ore from Yampi Sound will transport the billets to Kwinana on their return voyage.

With an eye to future possibilities, the rolling mill has been planned as part of a fully integrated works, though the first installations will not include iron and steel-producing facilities. Except for specialised equipment most of the mill will be constructed and fabricated in Western Australia. Market requirements within the State have been kept very much in mind and in this respect the mill will be unique. It will initially roll rounds (¼in to 2½in), flats (1in by ¼in to 7in by ¾in), squares (¼in to 2in), channels (3in by 1½in to 4in by 2in), angles (1in by 1in by ¼in to 3in by 3in by ¼in), and Y-bars (1·46 lb per foot). The installation at Kwinana will consist of an 18in, three-high breakdown mill, 12in roughing mill and 12in finishing mill, all electrically driven. The remainder of the works will include a 600ft jetty, warehouse space, fresh water treatment plant, electric sub-station, administrative, amenities, testing and store buildings, as well as a steel fence post plant. It is intended that the steel fence post plant will be the first unit in operation, using as its raw material Y-bars from New South Wales, and then, as the rest of the plant comes into production, bars rolled locally.

The jetty will be equipped with electrically operated cranes and warehouse space, and fuel oil and fresh water services for ships. Careful alignment of the berths will keep dredging at a minimum, and still allow a depth of at least 32ft alongside, sufficient for all but the largest vessels.

After unloading, the steel billets will be stored in the billet yard adjacent to the mill building. From the yard, they will go to a continuous furnace for heating to a suitable rolling temperature, ready for the breakdown mill. The final rolled product will then be cooled on a mechanically operated run-out bed.

Although the West Australian farmer and pastoralist will probably be the first to benefit from the Kwinana project in the shape of the steel fence posts, local development will receive a tremendous impetus when the whole plant comes into full production.

Mond Nickel Fellowships.—The Mond Nickel Fellowships Committee invites applications for Fellowships of an approximate value of £900 to £1200 for 1953. Fellowships will be awarded to selected candidates of British nationality with degree or equivalent qualifications, to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad, to make them more suitable for future employment in senior technical and administrative positions in British metallurgical industries. Each Fellowship will cover one full working year. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from the Mond Nickel Fellowships Committee, 4, Grosvenor Gardens, London, S.W.1. Completed application forms are required by June 1st.

Improving Coal Production

By E. H. BROWNE*

The Cadman Memorial Lecture, of which the following is an abstract, was delivered to the Royal Society of Arts, on Wednesday last, February 25th. The lecture stresses the cardinal factors which, in the author's view, are necessary to improved coal production, and emphasises that this country's coal industry must be developed to an overall national plan.

IN the last six years we have made significant progress in many aspects of coal mining ; much of this progress has not yet had immediately apparent results. But to-day, because I wish to concentrate attention on the things which need to be done, I shall to some extent ignore the record of achievement. I shall direct attention to our weaknesses rather than to our strength.

It will perhaps be useful first to give a brief summary of the trends of output and productivity in coal mining since the beginning of the century. The earlier and more recent figures are not precisely comparable, but the broad picture is as follows :—

Coal Output Trends

	Number employed	Output	Productivity		Annual output per man employed
			Face	Overall	
	Thousands	Million tons	Cwt. per manshift		Tons
1903–1912	936	254	Not available		271
Annual average :					
1913	1107	287	Not available	19·6	259
1922	1094	250	44·8	18·0	228
1927	998	251	50·0	20·6	251
1930	917	244	52·2	21·6	266
1933	772	207	54·7	22·4	268
1938	782	227	58·0	22·8	290
1948	724	198	58·4	22·2	273
1952	715	214	63·0	23·8	300

The peak of production was in 1913. After the disturbance brought about by the first world war the story is well known ; although the bleak prospects were not immediately obvious, the industry ran into increasing trouble throughout the 1920s, and by the 1930s the country did not want anything like the quantity of coal which was available. The position since the last war has, of course, been the reverse ; more coal has been wanted than could be produced, though the gap is now closing.

Productivity is a crude measure of efficiency, if only because it takes account only of part of the industry's total drain on the country's resources ; it ignores the materials and services which have to be provided from outside the industry. Costs are the only overall measure we have of human effort. Cost comparisons over the years are, however, made difficult by changes in wages and the value of money, as well as changes in statistical bases. Nevertheless, the following table gives the broad picture over the last forty years :—

Coal Production Costs

1909–1913	Cost per ton (saleable)	"Real cost" per ton† at 1909–1913 levels
	s. d.	s. d.
Yearly average	7 9	7 9
1913	8 8	8 3
1922	16 8	10 3
1930	13 6	11 4
1933	13 0	17 4
1938	15 11	14 3
1948	45 7	14 1
1951	49 2	9 10
1952 (nine months)...	56 4	11 11

†Related by the Sauerbeck Wholesale Price Index.

I shall not delay to consider how good or bad this trend has been, or the factors which have combined to make it so, but rather accept it as axiomatic that improved results must be obtained in the future ; and I turn to the big issues on which, I suggest, the future in fact depends.

* Director-General of Production, National Coal Board.

National Planning

Whatever views may be held about central economic planning in general, there can be no doubt that for coal mining it is essential. A national survey and a national plan were not only made possible by the unification of the industry : it was precisely that unification that brought to a head and made clearly apparent the need for an overall policy and plan for the development and reconstruction of the industry. That is what the national plan is—a broad programme establishing the future production levels in the various coalfields and the rate and extent of exploration and capital development in each. This plan had to be based on a comprehensive survey of production possibilities, which was then related to forecasts of demand : it had to be capable of being remoulded according to the new information which becomes available at any time—whether from the side of demand or from the unfolding of new knowledge of production capacity, for instance, about hitherto unproved coal reserves.

The plan, therefore, is on very broad lines, and by no means immutable ; it is a prerequisite for the proper development of the coal resources of the country ; it provides the framework within which the development and reconstruction of the industry must be worked out. It is true that there is a second and inter-related aspect of the plan : the build-up of individual schemes of reconstruction or new developments, which, though flexible and subject to revision in detail as each project is worked out or as conditions change, constitute the physical programme of reconstruction. But in its primary aspect the plan is a programme of production and investment targets.

The plan was related to an assumed demand of 230 to 250 million tons per annum, and for convenience the mid-point of 240 million tons per annum was used in the forward period reviewed, 1961–65. It was, however, clearly understood that this was not the maximum output available ; a larger production might be produced partly by maintaining more "marginal" pits at work—pits high in cost and low in productivity—provided, of course, that sufficient manpower was available.

The Ridley Committee has recently estimated in its report that the demand in ten years' time might be of the order of 260 million tons, but it infers, wisely if I may venture to say so, that the aim should be to reduce this potential demand by improving efficiency in the use of fuel ; and it is made abundantly clear that there is ample scope for this.

To aim for this larger capacity does not call for any significant change in the pattern of production of the plan. We can see ways in which the pattern needs to be reshaped here and there. For instance, we could not see, five years ago, how to utilise the full possible expansion of production of "general" coals from the Midland fields, attractive though these were from the point of view of production cost and available resources. But in the light of a closer examination of distribution problems and an increased forecast of electricity demand, it is now possible to postulate a larger production from these areas. Another assumption, which may need to be modified, was that opencast production would have ceased by 1961–65. It is now considered that opencast may still be able to help at that time.

On the other hand it is only possible to foresee an output equivalent to the Ridley committee's expectation of potential long-term demand under two conditions. First, that sufficient labour is available to enable us to maintain in production collieries which it had been hoped to close in the next ten years, and, secondly, an aspect which I shall emphasise in a moment, that the programme of reconstruction is really speeded up. It may, however, be open to doubt how far production ought to be pressed towards the maximum limits, because it is likely, in my view, that every increase in the output figure is likely to be accompanied by a sharp rise in the cost of production of the "marginal" tonnage. A proportion of total output is being produced to-day at considerable loss.

Now it is well known that the Board's price structure is not yet perfected and that it can only become so by stages : for this reason alone profits and losses are not, and perhaps, can never be, wholly reliable criteria. The highest cost element includes special kinds of coal—anthracite, and some of the coking coals. In addition the variability of colliery results is much greater than that of other industries and high losses will not necessarily be prolonged in individual cases whilst profitable pits have their bad spells. Short-term "marginals" are not necessarily long-term ones. But profits are the only overall measure ; and although they do not indicate precisely where the coal should be got, they show up the significance of marginal tonnage on the economy of the industry as a whole.

How will this be in the future ? It is impossible to forecast actual costs owing to uncertainties about the changing values in money, in relative wages, prices of materials and so on. But we can form a judgment of how the cost pattern of total tonnage will be likely to move. The elimination of the worst elements will, of course, help to reduce the disparities ; and the reconstruction programme will, by raising substantially the efficiency of the surface, of the shafts, and of the underground transport systems of many collieries, exert a strong force compressing the limits of the costs bracket.

On the other hand, other factors will work in the opposite direction. Face productivity will in the future be governed by new kinds of mechanisation and new face techniques. All the indications at present are that new methods and machines will achieve success more readily in the easier conditions, where productivity is already higher than the average. Heavily faulted strata, high inclinations, and similar difficult mining conditions present considerable obstacles to mecha-

nisation ; thin seams, though no doubt susceptible to new techniques of coal-getting, restrict the manœuvring of machines and militate against the use of those which are adaptable to thicker sections ; and thin seams do not offer the concentration of production which is possible from thick seams. Roof control problems and high gas emission, which are often (though not always) associated with great depth, are impediments to increasing mechanisation. Thus in general the easier the conditions the better the chance of introducing new machinery and techniques ; and from this it follows that we may expect the advantage conferred by favourable physical conditions to increase rather than diminish. In this connection we must not close our eyes to the fact that coal is getting more difficult to mine every day. The shallower coals, the thicker seams, have almost invariably been, and are still being, taken first. Many reconstruction schemes are being undertaken not solely or even primarily to improve efficiency (though they carry this with them) but are to develop new seams, and these new seams are more often than not deeper, thinner or inferior to those which have been got before.

In addition—and this is important—any trend towards equalisation of wages between districts will widen the disparities of cost yet further : although there are notable exceptions, the low productivity coalfields in the main tend to-day to have lower wages than the high productivity areas. Historically this situation is understandable : but a movement away from it will inevitably exaggerate the differences in cost between the high and the low productivity regions. It seems likely, therefore, that the rate of increase of cost in the marginal zone will rise very rapidly indeed in the long term ; and every extra ton produced will add an increasing burden to consumers as a whole. What is the moral of all this ? If my prognostications are right they show how urgent and vital is the need to minimise the consumption of coal ; in the national interest capital expenditure on means to effect economy should not be related to average costs of coal production, but to a very much higher figure ; and to aim for the biggest total output which is technically possible may not be as attractive a proposition in national economics as a superficial knowledge of the situation might suggest.

The Reconstruction Programme

Turning now to the other sense in which the " National Plan " is used, there will be no need for me to emphasise that the comprehensive physical reconstruction of the collieries is urgent. This formidable task of reconstruction and development remains, at the moment, a matter of anxiety. The programme has not kept up to schedule for a variety of reasons, some of which have their origin in the industry's own weakness. It is no secret that the mining industry was not geared up to planning and executing a vast reconstruction programme. Moreover, it is an inescapable fact that it has been backward in its technical organisation and particularly weak in respect of planning. Another influence which has operated against progress has been the pressure for immediate production, and the conflict between this and the long-term objective.

The rate of capital investment of the industry has improved a little lately, the result after a long time lag of schemes initiated two, three or four years ago now getting into their stride. Capital expenditure on the collieries only compared with that envisaged in the National Plan estimates has been as follows :—

National Plan Requirements

Year	At 1949 prices, £ million	Adjusted for price increases, £ million	Actual expenditure, £ million
1950	30	32·5	24·6
1951	37	46·4	26·5
1952	43	58·9	36·0 (estimated)
1953	40	56·9*	—
1954	36	51·2*	—
1955	34	48·4*	—

* At 1952 prices

These figures relate to total capital expenditure at collieries. They are therefore somewhat deceptive as regards the reconstruction programme since they include all the minor spendings, short-term projects and portable or other equipment needed for current purposes. In the early years of nationalisation expenditure on the latter was inflated by immediate requirements, partly to recover ground lost during the war years and partly to raise standards of equipment at the backward collieries. Expenditure on the larger schemes, those costing over £500,000 has been as follows :—

Year	Total expenditure collieries only	Expenditure on schemes costing over £½ million	Per cent of (*b*) to (*a*)
	£ million		
	(*a*)	(*b*)	(*c*)
1947	14·6	0·56	4
1948	20·9	1·51	7
1949	27·0	2·81	10
1950	24·6	4·93	20
1951	26·5	6·73	25
1952 (estimated) ...	36·0	12·0	33

If we are " to improve coal production " in the sense of producing anything like 250 million tons per annum at a reasonable average cost and without an excessive volume of high cost tonnage ; if indeed we are to produce that level of output at all, we must speed up the reconstruction and development of the collieries, within the framework of a National Plan designed to give the best overall exploitation of the coalfields of the country.

The Coal Face

For a long time the industry has employed the orthodox British longwall system (adopted widely as greater depth and difficulties led to the displacement of bord and pillar systems) usually with coal cutting and conveying and working on a twenty-four-hour cycle of operations. The concept of this method has not changed over twenty or thirty years, but the proportion of output got by it with the help of machinery has risen very substantially ; and so has the quality of the equipment. The orthodox way of assisting the *coal getting* process by machinery is the slotting of the seam with coalcutters to provide the relief needed to make blasting safe and effective. The proportion of total output of coal cut mechanically in this way rose from about 31 per cent in 1930 to 58 per cent in 1938, and is now over 80 per cent. About 8500 coalcutters with an aggregate horsepower of 375,000 are employed. About 10 per cent of total production is got with pneumatic picks ; and there is a certain amount of soft, easily won, coal for which no mechanical aids are required. The drilling of shotholes by means of electric or compressed air is now universal. Since 1938 the number of mechanical drilling machines used in coal has grown from about 3900 to over 12,300.†

In the process of *carrying* the coal, shovelling into a small tub and manhandling the tub from the face to the haulage road has been very largely replaced by mechanical conveyors. A year ago nearly 200 million tons were conveyed on the face and only 28 million tons loaded into tubs. Over 400 miles of conveyor has been installed on the face, and a further 1400 miles of conveyors were in use on the roads, making about 1800 miles in all. The proportion of coal moved in this way either on the face or in the roads increased from 53 per cent in 1938 to about 90 per cent. This has meant a considerable increase in the amount of conveying equipment. In 1922 there were about 930 face conveyors ; in 1938, 5620 ; to-day nearly 10,000.† The figures for roadway conveyors are not available so far back ; but since 1938 they have increased from 2200 to about 9500†.

These processes of loosening the coal and conveying on the face have thus been very widely developed ; there has not yet been a large scale mechanisation of the intermediate process between the two, that of loading the coal on to the conveyor, though a good deal of pioneering work has been done. Only about 5 per cent of the present output is power loaded.

The first power-loading machine to replace the shovel to any substantial extent was the Meco-Moore, which, after more than ten years of trial and development, came into effective use in 1944. To-day there are about 100 machines in use loading about 6,000,000 tons of coal per annum. This is as yet the only significant contribution, in terms of tonnage, to real mechanisation of the coal getting process. In the last ten years a number of other machines employing cutting chains have been designed : some have failed partially or completely ; others are still in the experimental stage and show varying degrees of promise. There is a second way of attacking the coal, in the manner of a plane or a plough, shearing it from the coalface in slices. Several machines of this kind are being used and while some of them have met teething troubles others are very promising, particularly the various forms of coal ploughs brought over from Germany and now being developed in this country. There seems little doubt that ploughing in one form or another will have an important contribution to make.

There are other quite different kinds of machines on trial and some used to a limited extent on production, such as the bord and pillar continuous miner from the U.S.A.; and experimental work will soon be done with augers—large drilling machines which bore out the coal. The application of these may be limited, but they are interesting lines to be pursued for special purposes. Moreover, continuous miners on American lines may prove adaptable to longwall work. It has, however, to be admitted that the effective contribution of power loading is still very small, and so far as results to-day are concerned it is therefore necessary to judge mechanisation of the coal face primarily in terms of getting and carrying the coal to the roads. The increase of mechanisation within this limited field is reflected in the horsepower installed per face worker, which has increased since 1943 from 1·34 to 2·05. Moreover, the improvement in the quality of equipment has been great in recent years. Since the vesting date about 4100 new coalcutters and 15,500 conveyors have been supplied to the collieries at a cost of about £20,000,000 (excluding spares and belting). Equipment in this category supplied in the year 1951 alone cost £4,000,000.

As regards the processes on the face associated with coal getting—the setting of temporary roof supports and withdrawing them, the building of packs or other per-

† The differences are actually greater owing to a statistical change.

manent roof supports, the construction of roadways at the face and the provision of services—some improvements are on the way. Supports which are adjustable in height and fitted with devices for quick setting and quick release are being introduced rapidly ; over 85,000 of such props are in use. These not only reduce the amount of labour involved, but they give better roof control, an extremely important factor in coal face work. The building of packs by mechanical means has received much thought and experiment in the last ten years, and both pneumatic and mechanical devices are now in use. The number of machines has risen from six in 1947 to seventy-five at the end of 1951. The majority of these are pneumatic, but some are mechanical. This is a field where much pioneering work remains to be done. The latest " armoured flexible " conveyors do not have to be dismantled and rebuilt for moving forward to new positions as coal is extracted. They are advanced as a whole, usually by power-operated jacks. They not only reduce the amount of labour involved, but also provide opportunities for minimising the amount of working face exposed, and, in conjunction with new kinds of support, they help towards improved roof control.

Now it may well be said that with the new machinery even if most of it is on orthodox lines, and with improvement in local layout at many collieries, the increase in face productivity has been disappointing, even after allowing for the fact that we are moving always to deeper, thinner and less easy seams. In fact, it has risen from 52·2 cwt in 1930 to 58 cwt in 1938, and was about 63 cwt in 1952. But whether these figures are disappointing or not, it is certain that we must do better. Face productivity is fundamental to our overall efficiency. The machinery which we have at present, and even the promising ideas on which we are working, will not be enough ; we must seek for really new methods at the face. While the reconstruction of the collieries can give computable results we do not know what can be achieved in coal face work. The field is one for imagination and initiative. The results will be profoundly important.

Technical Management

It is peculiarly ironic that the industry should so often be criticised for having a top-heavy force of officials ; for the truth is that, especially in relation to the complexity of coal mining to-day, its technical management is extremely " light."

It is not, however, just a question of numbers : the industry needs to develop a more modern system to meet the complicated needs of the day and the future. The general pattern of organisation set up by the National Coal Board has, of course, brought about the creation of a " vertical " chain of command ; this is the automatic effect of integration. But the essential structure and methods of technical management have remained much as they were. Indeed, in my view, coal mining has inherited a concept of technical control which is out of date in the twentieth century and impotent in the face of the tasks of to-day. In its infancy and youth the mining of coal was a kind of natural art or a craft ; but to-day it is an industrial engineering complex, technically as elaborate as any, and one of the most exacting ones in the world to manage.

If we are to " improve coal production " I believe that planning work must be recognised as being of equal importance with operational management ; that a new conception of technical management is needed in the industry which makes a division between the two ; and that we must be ready to share the available mining engineers between these two needs. The service branches need strengthening and modernising and in some places should have a bigger role. " Bottle-necking " is often the obstacle to efficient control. The mechanical and electrical engineering services need reinforcement, and civil engineering, now weak, needs to be built up. These engineers must also be given proper status in the industry and allowed to function properly as services, if engineering standards are to be raised. So, too, the small but important branch of coal preparation engineering needs building up. The techniques of coal cleaning are now so highly developed that they demand specialisation and the function of this branch is to exercise technical control of cleaning plants, to plan extensions and to be responsible for the quality and grading of finished products. It bridges the gap between production and marketing.

Production of a Heavy-Duty Wilson Gearbox

An account is given in this article of the methods used by Guy Motors, Ltd., in the production of epicyclic gear components for a Wilson four-speed gearbox, which is used in conjunction with a Gardner 112 b.h.p. diesel engine. Reference is made to certain other major components and a brief description of the operation of the box is included.

AMONGST the concerns now producing the Wilson gearbox under licence is Guy Motors, Ltd., which fits this unit to a proportion of its heavy road vehicle chassis. In the course of a short visit to the company's works at Wolverhampton we were able to see some of the more important operations in its production. A light duty Wilson gearbox was first described in THE ENGINEER in 1931* and it has been the subject of two papers by Major Wilson before the last war.

It is therefore only proposed here very briefly to outline the principles of the torque transmission in order to identify the major components in its construction.

Although three types of gearbox are manufactured by the company, namely, four-speed and reverse, five-speed and reverse, and four-speed, reverse and overdrive, this article is primarily concerned with the first named, which is coupled through a fluid flywheel to a 112 b.h.p. Gardner diesel engine.

The illustration, Fig. 1, shows a sectional drawing of the four-speed box and a diagrammatic representation of the torque flow during first gear engagement is given in Fig. 2. This first gear train in the Wilson box acts as a primary train for all other gear ratios (except top gear), the function of the other epicyclic trains being either singly or collectively to increase the speed or change the direction of its annulus.

Thus, it may be gathered from Fig. 2 that the first gear ratio is obtained by braking the annulus of this primary train. The sun wheel of this train is splined to the input shaft and the planet carrier to the output shaft. The second gear ratio is obtained by braking the second train annulus and releasing the annulus of the primary drive, which remains free for all other ratios. In this case its spider is forced to rotate by the sun wheel, which is actually integral with the primary sun wheel. This spider being integral with the primary annulus, causes the primary spider and hence the output shaft, to rotate at increased speed. Third gear results from braking a drum integral with the third train sun wheel, this being freely mounted in a bush on the input shaft. As the primary annulus, the second train spider and third train annular can be regarded as of integral construction, the latter consequently rotates in the direction of the engine, causing the spider of the third train, which is coupled to the second train annulus, to rotate in the same direction. The sun wheel and the annulus of the second train

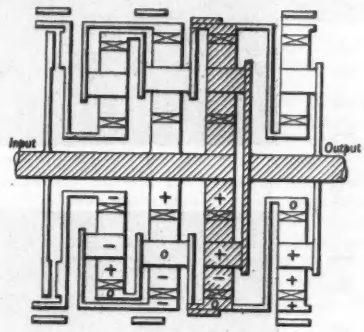


Fig. 2—Torque Flow Diagram for First Gear

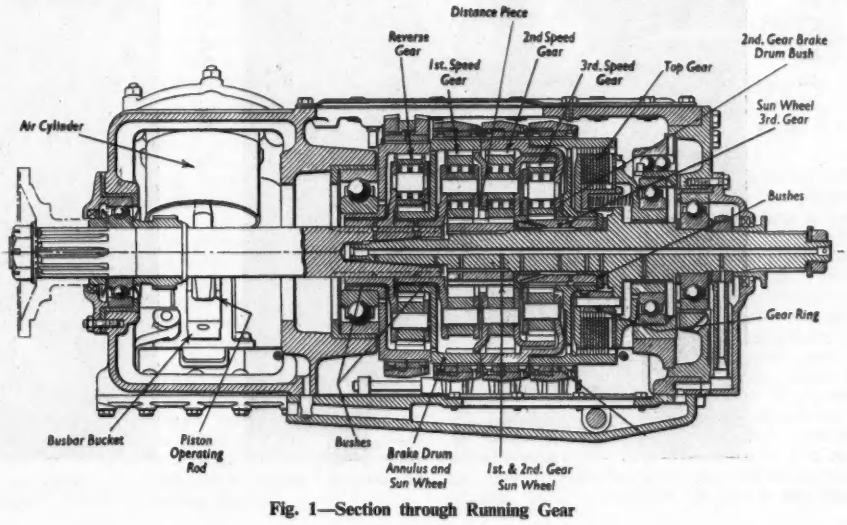


Fig. 1—Section through Running Gear

* THE ENGINEER, March 20, 1931, page 310.

PRODUCTION OF A HEAVY-DUTY WILSON GEARBOX

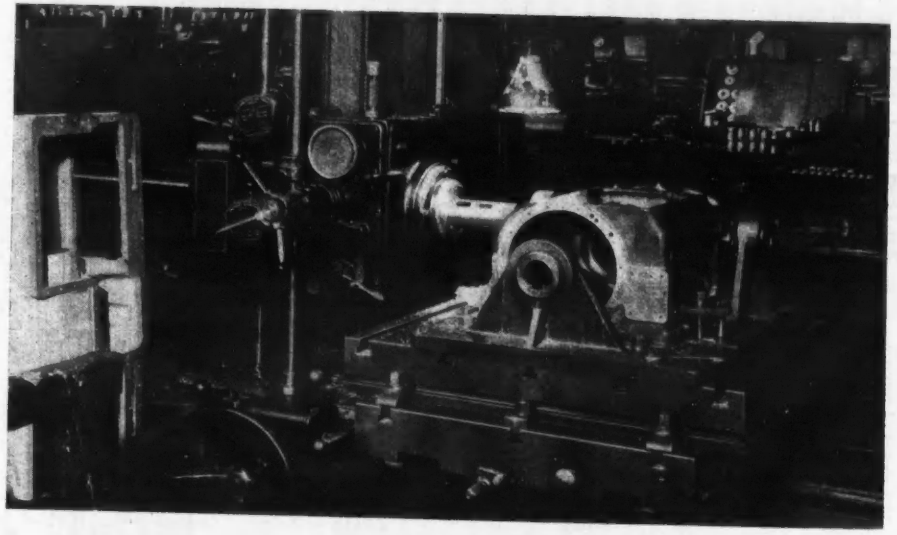


Fig. 3—Machining Gearbox

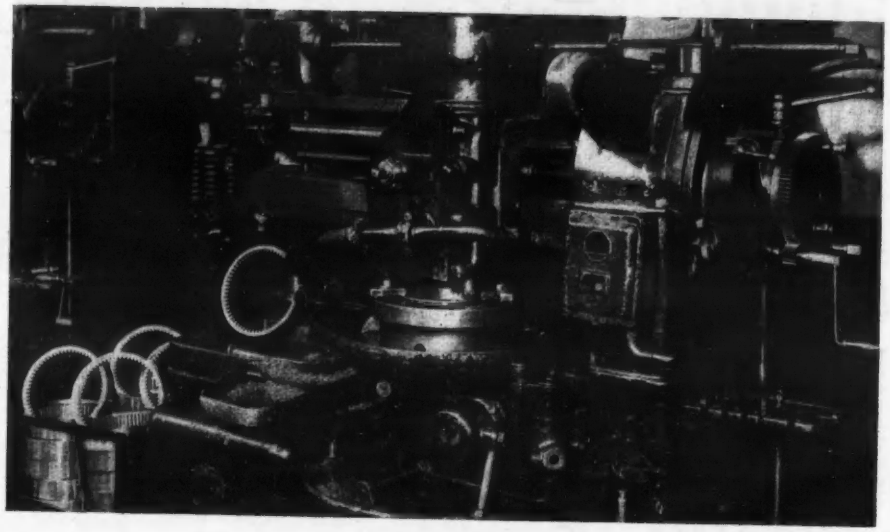


Fig. 4—Cutting Internal Teeth

Fig. 5—Grinding Planet Wheels

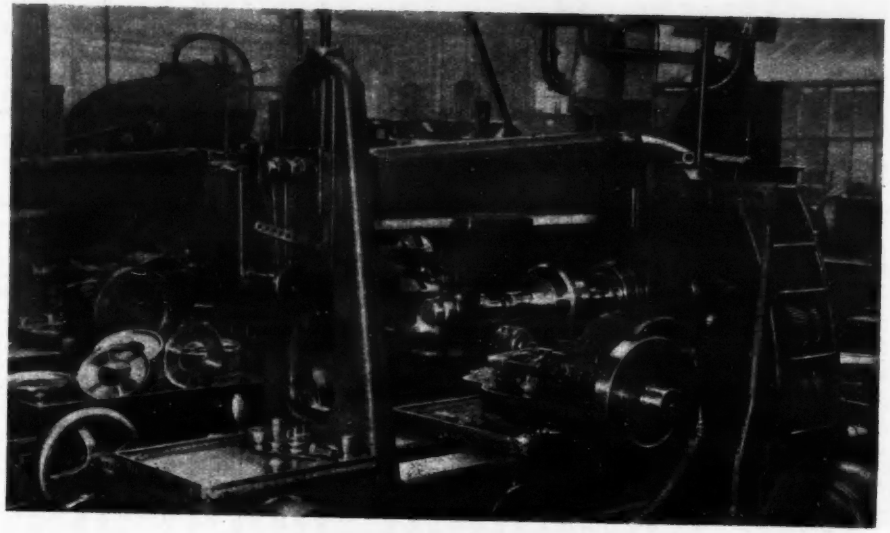


Fig. 6—Hobbing Dished Plate Gears

are thus rotating in the direction of the engine, and the spider of that train rotates at a higher speed than when its annulus was anchored, so that a further increase in speed of the primary annulus is obtained causing the primary spider and hence the output shaft to rotate at higher speed. Top gear is obtained by clutching the sun wheel of the third gear train to the input shaft. Here all the planet wheels in the system are stationary on their pins and the whole rotates at the same angular velocity. At all other times all the planet wheels rotate.

By use of an auxiliary train the primary annulus is rotated backwards at such speeds that though

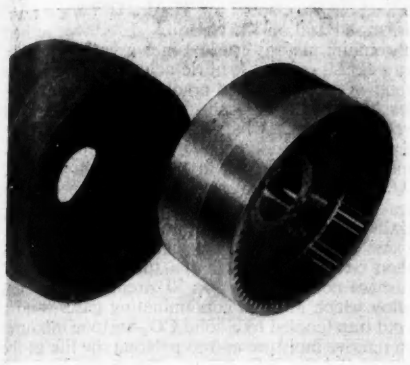


Fig. 7—Third Gear Brake Drum

the sun wheel rotates forwards, the spider, and hence the output shaft, is reversed.

The machine tools, where employed almost solely for the production of components for the Wilson box, are suitably grouped and located in the main machine shop to serve conveniently a floor space where the units are assembled.

The base plates, gearbox main casing and covers are "Elektron" castings and facing and boring operations using jig location are carried out on standard Herbert and Cincinnati milling and Kearns boring machines. Our illustration

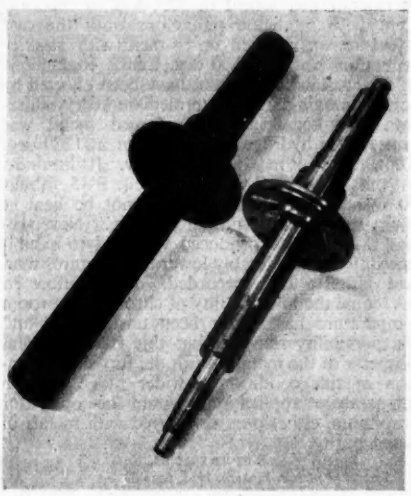


Fig. 8—Input Shaft

(Fig. 3) shows face milling operations on a box jigged on a Kearns horizontal boring machine. Drilling operations are largely carried out with Asquith single-spindle radial-arm machines.

A great number of the internal components are formed as drop stampings and supplied to the machine shop as blanks, among them being all major components of the gear trains. With the exception of the sun wheels and planet wheels all material used is 4 S.11, which is tempered after machining, the pinions being of much tougher steel (S.82) and are subsequently case hardened. As it is a particularly fundamental need to ensure concentricity in a compound epicyclic gear, all toothed members are located from the bore where possible.

As can be appreciated from the drawing, units such as the first speed brake drum, having internal teeth, must be cut on gear shaping machines. In Fig. 4 Fellows machine is shown working on an annular gear. This component, however, is only used in the five-speed box.

A construction which affects the third-speed brake drums is shown in Fig. 7. The brake drum for the first-speed gear forms the annulus for the primary drive and the sun wheel of the reversed train, and it is in permanent tooth engagement with a dished plate gear, thereby acting as the annulus also for the second gear train. The sequence adopted is to finish-machine the sun wheel, which is case hardened and ground. The annulus of the brake drum is then rough turned and the bore finish turned. The smaller annulus is then broached and the sun gear pressed on to it. Then locating from the bore of the sun wheel, the drum is finish-turned, the outside diameter being ground. It is finally transferred to the Fellows machine, where located from the brake drum, the internal teeth are cut. A similar sequence is followed with the third gear drum (Fig. 7), in this case the brake drum and the sun wheel for that train are integral.

Perhaps the most important detail affecting the life of the gearbox is the radial and axial alignment of the planet wheels in the spiders, and the extent to which their teeth profiles are identical. In accordance with the latter requirement, the planet wheels are hobbed on Cleveland rigid, vertical hobbers to within 0·004in over most of the profile with closer limits at the root. After case hardening and shot blasting, they

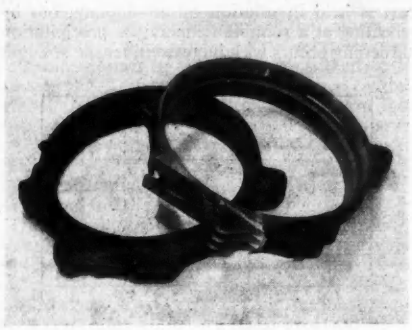


Fig. 9—Brake Band Partially Machined and Blank

then pass to Orcutt gear grinding machines, where they are ground in sets of three (Fig. 5). Here the formed wheel method of grinding is used and the correct involute maintained by diamond dressing of the wheel after every two cuts. It is to assist the life of the grinding wheel tip that much closer hobbing limits are observed at the tooth root.

Special jigs are employed for the drilling and assembly of the planet carrier plates and their planet wheels. In the reverse train and the primary train the planet carrier sets are formed by two plates between which the planet wheels, mounted on roller bearings, are located. The roller bearings are secured to spindles which are riveted over in the carrier plates. Rivets are also used to clamp the carrier plates to the distance pieces. Both the carriers for these trains are splined to the output shaft. The splines are machined on Barber Coleman hobbing machines. Another jig is used to locate the spider of the second gear train, which combines on one side plate the annulus for the third train and on the other a tooth disc which is in permanent engagement with the teeth adjacent to those forming the annulus in the primary drive drum. In Fig. 6 these discs are shown being cut in pairs on a Barber Coleman horizontal hobbing machine. The distance pieces and pinions are likewise secured by riveting.

This component fits axially inside the second gear brake drum so that the annulus on the side plate engages with the first gear planet wheels, and its own planet wheels engage with the annulus integral with the drum. Thus, the second gear brake drum comprises the planet set for the third gear train and the annulus with the second gear train, and it rotates freely on the input shaft on gunmetal bushes.

Top gear is obtained by locking the input shaft to the output shaft, the former carrying a flange, to which is bolted a gear ring. This ring engages with internal teeth on alternate discs along its length, the intermediate discs having external teeth which engage with internal teeth with the third gear brake drum. Thus, locking these plates by axial pressure causes the sun wheel integral with the brake drum to rotate at engine speed, so that all the sun wheels are rotating at the same speed.

The coaxial alignment of the input and output shafts is readily apparent from the drawing. These are also drop stampings in nickel chromium

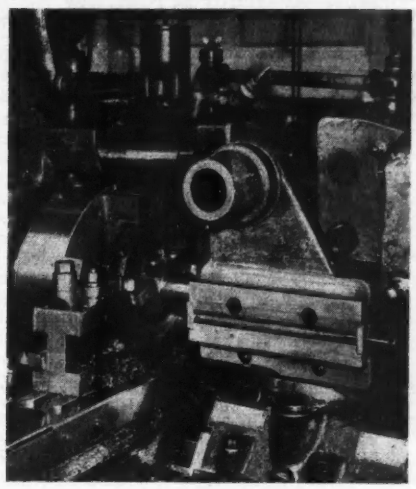


Fig. 10—Machining Brake Band

steel and are heat treated before machining. Our illustration (Fig. 8) shows the input shafts before and after machining. It is formed with a flange to which the gear-ring is riveted. Its splines are finished on Orcutt spline grinding machines and the journals, which spigot in the output shaft, are amongst other diameters which have a ground finish. Fig. 9 shows the stamped blank and a finished brake band, from which the milling, boring, facing and drilling operations involved in this important component can be deduced.

Fig. 10 shows one of the first operations where facing and boring are in progress on a Herbert

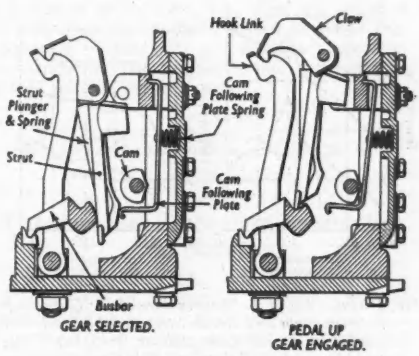


Fig. 11—Operation of Brake Bands

No. 4 chucking auto. The final operation is the axial cut across the band. These brake bands are so anchored that they impart only a pure couple to the drum.

Operation of the selector lever (Fig. 11) rotates a camshaft which has indexing cam profiles. For the particular gear required, the spring-loaded cam following plate is released and forces the strut against the busbar which runs longitudinally. When engagement of this particular gear is required, operation of the foot pedal causes the busbar to pivot downwards on its knife edge and engages the strut, whereupon the release of the pedal allows the busbar to rise upwards, urged mechanically or pneumatically. The claw has then rotated the hook link, which, in turn, engages with a shoulder on the brake band.

Metallurgical Topics

High-Tensile Structural Steels

THE demand for high-tensile weldable structural steels has led F. Nehl[1] to make a study of steels of the manganese-silicon type with a view to modifying their composition to give the highest possible yield ratio (ratio of yield point to tensile strength). The influence of grain size on yield ratio is well known. In a steel with carbon 0·1 per cent and manganese 0·4 per cent, the ratio point falls with increasing normalising temperature between 900 deg. and 1250 deg. Cent. (which results in increasing grain size) from a little over 60 per cent to a little over 50 per cent. The yield ratio is also markedly

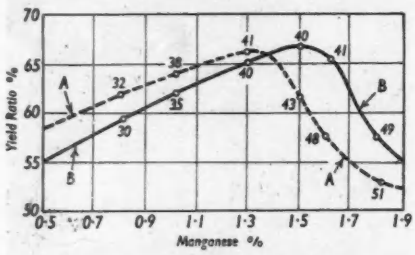


Fig. 1—Relation Between Yield Ratio and Manganese Content of Steels with Carbon 0·15 to 0·20, Per Cent and Silicon 0·40 to 0·50 Per Cent. Curve A—Air-Cooled 100 Deg./Min. Curve B—Furnace Cooled 10 Deg./Min. The numbers give tensile strength in tons per square inch.

affected by manganese content. Fig. 1 shows this relation for furnace-cooled and air-cooled manganese-silicon steel containing carbon 0·15 to 0·20 per cent and silicon 0·4 to 0·5 per cent. The tensile strength increases regularly with increasing manganese content, but the yield ratio reaches a maximum at 1·5 per cent manganese (furnace cooled) and at 1·3 per cent (air cooled). Microstructure showed that the increase in yield point and yield ratio was caused by the products of intermediate-temperature transformation (bainite structures) without embedded martensite. Since these areas consist of ferrite with fine sub-microscopic carbide dispersions,

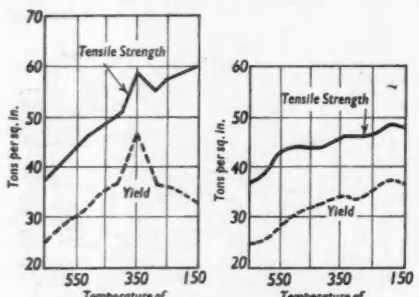


Fig. 2—Influence of the Temperature of the Quenching Bath on Yield and Tensile Strength of a Steel with Carbon 0·20 Per Cent, Silicon 0·45 Per Cent, and Manganese 1·2 Per Cent After Quenching from 870 Deg. Cent. in a Salt Bath.

Fig. 3—The Same Steel Treated as Shown in Fig. 2 and Subsequently Heated for One Hour at 600 Deg. Cent. and Cooled in Air.

they afford strong resistance to slip and result in a rise in yield point and yield ratio.

Specimens of steel containing carbon 0·2 per cent, silicon 0·45 per cent and manganese 1·2 per cent were heated at 870 deg. Cent. and quenched in salt baths at different temperatures between 650 deg. and 150 deg. Cent., and held for forty minutes to complete the transformation. The results of tensile tests (mean of two specimens) are shown in Fig. 2. When transformation occurred at temperatures below 350 deg. Cent. the yield point suffered a sharp reduction, though the tensile strength continued to rise. This fall in yield point was corrected and the properties improved by reheating for one hour at 600 deg. Cent. and cooling in air (Fig. 3).

Further improvement in strength may be sought by the addition of elements which, by providing carbide or nitride particles of critical size, introduce further resistance to slip and effect an increase in yield strength. Such elements must be used in strictly limited quantities. Nehl gives the limit for chromium as 0·5 per cent and states that vanadium, titanium or tantalum plus niobium should not exceed 0·2 per cent. These elements in the austenite may cause a marked lowering of the transformation temperature resulting in the presence of martensite in the region of a weld. This is particularly so when chromium and vanadium are present together. Aluminium, by the formation of nitride as well as by grain refinement, may give increased yield point. This is discussed in another paper published at the same time.[2]

Taking advantage of the precipitation hardening property of copper steels affords a further possibility of raising the yield point and improving the yield ratio. The suggestion to use copper steels for structural purposes has long been familiar. In Germany, copper-nickel steels have had a limited application for boilers. The copper must be over 0·6 per cent. The greater part is held in solution on air cooling, but by reheating at a suitable temperature precipitation hardening occurs with increase in tensile strength

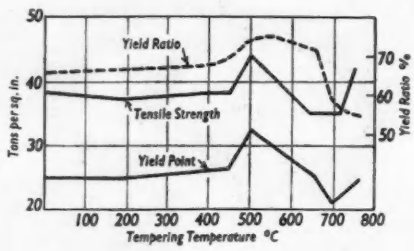


Fig. 4—Yield Point, Tensile Strength and Yield Ratio of a Copper-Nickel Steel, Normalised, Reheated to Different Temperatures and Cooled in Air. Composition: Carbon 0·18 Per Cent, Silicon 0·38 Per Cent, Manganese 0·65 Per Cent, Copper 0·85 Per Cent, and Nickel 0·65 Per Cent.

and to a greater extent in yield point. At the same time a certain degree of brittleness appears. Fig. 4 shows the result of heating a normalised sheet of copper-nickel steel, 70mm thick, at different temperatures for one hour. The influence of precipitation is first shown by heating at over 450 deg. Cent. Heating at 500 deg. Cent. produced the maximum effect. Experiments undertaken with the object of improving the strength at elevated temperatures of copper-nickel steel of the type referred to in Fig. 4 by carbide inclusions of critical particle size indicated that an addition of 0·2 to 0·3 per cent of molybdenum or vanadium and under 0·03 per cent of tantalum plus niobium or of titanium was enough to improve the ratio of yield strength at 350 deg. Cent. to tensile strength at room temperature of these steels after normalising and tempering below 650 deg. Cent. (All the suggested improvements, it will be noted, require the application of a heat-treatment subsequent to normalising.) With a room temperature tensile strength of 35 tons to 40 tons per square inch it was possible to get a yield point at 350 deg. Cent. of 22 tons per square inch. Long-time experiments of over 10,000 hours' duration at 350 deg. Cent. showed that the unusually high yield at this temperature was maintained after prolonged stressing and that there was no embrittlement.

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Forging of Arc-Melted Chromium

THE U.S. Bureau of Mines N.W. Electrodevelopment Laboratory has systematically re-examined the most promising methods of producing high-purity chromium from electrodeposited chromium, which is the purest form of the metal commercially available. It favours the hydrogen reduction method, and the exact form in which this process is used is described in a paper by H. L. Gilbert, H. A. Johansen and R. G. Nelson.[1] Electrodeposited chromium plate is crushed in a gyratory crusher to pass 60 mesh. A nitric acid leach is used to remove the iron picked up during crushing. The leached powder is washed in distilled water and vacuum dried. Charges of chromium powder are loaded in molybdenum boats into 2in diameter porcelain tubes in the reduction furnace. After this has been evacuated and checked for leaks, hydrogen is admitted through a purifying train of palladium catalyst and phosphorus pentoxide to free it from oxygen. The hydrogen is then circulated through the tubes, a "getter" furnace containing a 50 : 50 zirconium-titanium alloy which absorbs contaminating gases, and a cold trap (cooled by a solid CO_2-acetone mixture) to remove moisture and so prolong the life of the getter and the P_2O_5 tubes. The temperature of the getter furnace was 890 deg. Cent.; that of the reduction furnace 1100 deg. to 1200 deg. Cent. for sixteen hours. A hydrogen reduction process for obtaining high-purity chromium is employed at the Fulmer Research Institute, but the reduction temperature used there is 1450 deg. Cent. for four hours.[2]

The technique of melting adopted by the authors resembles that used in the arc melting of molybdenum and vanadium, i.e. arc melting in an inert gas on to a water-cooled copper hearth, thus rendering contact with refractories unnecessary at any stage of the process. It is not a method by which castings of special form can be produced, but is suitable for metal which has to be rolled or forged. The arc-melted chromium was forged at 800 deg. to 850 deg. Cent with moderate reductions until the cast structure was broken up; then with heavier reductions down to 500 deg. Cent. Reductions of as much as 93 per cent have been effected by rotary swaging. An intermediate recrystallisation was beneficial. The forged metal was annealed in hydrogen for one hour at 1200 deg. Cent. to give it maximum ductility. Its hardness in this condition was Rockwell B 45 (about 90 Brinell). Even so, it could not be bent at room temperature without fracture. Nevertheless the metal so produced was said to exhibit ductility at considerably lower temperatures than had hitherto been recorded. Every effort to overcome the low ductility of chromium at room temperature has so far been unsuccessful and the possibility remains that this is an inherent property of the metal. With the further elimination of this condition a wider range of high temperature applications would be open for chromium, either pure or alloyed with metals of equal purity.

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Energy Stored in a Metal During Plastic Deformation

THE change in internal energy of a metal during plastic deformation is of great theoretical interest and numerous attempts have been made to measure it; the latest is described in a paper by L. M. Clarebrough, M. E. Hargreaves, D. Michell and G. W. West,[1] who, so far, have applied it only to high-purity copper. These authors first refer to several methods which have been used in the past. The first to be employed was determination of the difference between mechanical energy expended in deforming the specimen and the energy evolved as heat during the deformation. This method has been applied to a wide range of steels and other metals with, on the whole, consistent results in spite of the fact that these depend on relatively small differences

between two larger quantities.[2] A second method was comparison of the heat of solution of a deformed and an annealed specimen of the same metal. The value of the stored energy is calculated from the difference between the observed changes of temperature on dissolving the two samples. The original work with this method was that of M. B. Bever and L. B. Ticknor,[3] in which cold-worked silver and gold-silver alloy were dissolved in molten tin. The results, however, showed considerable scatter and were not reproducible to within ±30 per cent. The method has not been applied to copper. A third method has been the determination of the heat content of annealed and deformed specimens of equal weight between the temperature of

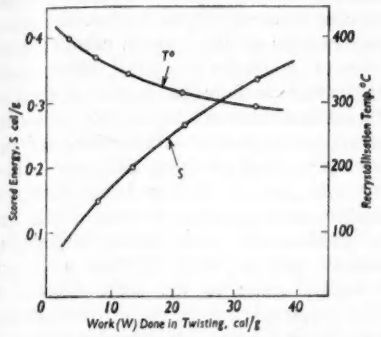

Fig. 1—Energy Absorbed During Deformation of Copper, and Recrystallisation Temperatures Clarebrough et al).

deformation and a second temperature sufficiently high to allow the release of all the energy stored during deformation. There were several variations of this method. S. Sato[4] placed an annealed and a deformed specimen in similar holes with a silica lining in a block of silver. The block was heated and the difference in temperature which developed between the specimens was measured. Sato showed that much less energy was stored by pure metals than by alloys, and that the ratio of energy absorbed to work employed in deformation diminished as the work applied increased. Copper was among the materials examined and the proportion of energy absorbed was found to be about equal to that absorbed by silver and about 2½ times that

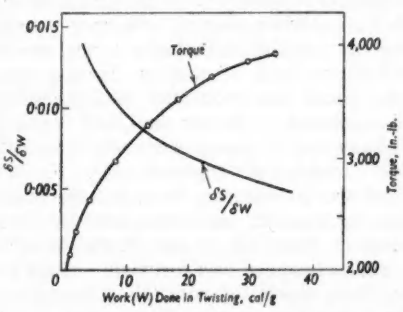

Fig. 2—Torque Required to Produce Deformation of the Copper Specimens

absorbed by pure iron. G. Bockstiegel and K. Lucke,[5] in determining heat of recrystallisation of copper, heated, annealed and deformed wire side by side. The energy stored was calculated either from the temperature difference between the wires or from the additional electrical energy which had to be supplied to annealed wire to reduce this difference to zero. H. Quinney and G. I. Taylor[6] (who had also used the first method[7] referred to above) used two identical furnaces, heated by the same current, the annealed specimen being placed in one and the deformed specimen in the other. The temperature difference which developed between the two specimens as the stored energy was released was measured. An objection to this arrangement was that the heat capacity of the specimens was small compared with that of the furnaces, and any temperature difference due to some possible lack of identity of the furnaces would be an appreciable part of the total difference observed. Quinney and Taylor also designed a calorimetric furnace and by development of this idea Clarebrough, Hargreaves, Michell and West[1] constructed the apparatus with which their measurements were made. Their method involved heating *in vacuo* an annealed and a deformed specimen of equal weight by small heating elements located inside each specimen. During the heating the specimens were kept at the same temperature as each other, and were surrounded by a metal shield continuously adjusted to this temperature. The stored energy was calculated from measurements of the difference in power supplied to the specimens, made by means of a differential wattmeter constructed for the purpose. The apparatus proved to be capable of measuring, with an accuracy of ±5 per cent, a difference of 0·1 cal/g in the energy supplied to the specimens in heating them through a temperature range of 240 deg. Cent. in a period of forty minutes.

Results are given for specimens of electrolytic copper deformed in torsion, and they show that the stored energy increased with deformation in a similar way to the torque required to produce the deformation. Curves for copper containing phosphorus 0·0065, oxygen 0·0013 per cent (copper 99·97 per cent) are shown in Figs. 1 and 2. A copper containing phosphorus 0·0021, oxygen 0·0053 per cent (copper 99·98 per cent) had a recrystallisation curve parallel to, but about 120 deg. Cent. lower than, the curve in Fig. 1; but the curve representing the total stored energy was almost identical with that in Fig. 1. A striking feature of the results is the disagreement of the present measurements with those of Taylor and Quinney, though both series are consistent in themselves. Taylor and Quinney obtained, for the percentage energy absorbed by copper over the greater part of the range of deformation, a value of about 8 per cent, whereas the results shown in Fig. 1 are equivalent to a value of about 1 per cent. It is suggested by the authors that differences in composition are the cause of discrepancies between their results and those of previous workers, and they produce evidence to show that the copper employed by Taylor and Quinney contained 0·45 per cent of arsenic and 0·035 per cent of phosphorus.

There would appear to be substantial grounds for considering that composition may have a great effect on the energy absorbed when it is recalled that W. Rosenhain and V. H. Stott,[8] who measured the work done and the heat produced when a length of wire was drawn through a die which was enclosed in a calorimeter, found an intermediate value of 3·1 per cent for the percentage energy absorbed by copper. The analysis was not given, but the tensile strength of the annealed specimen (16·1 tons per square inch) was 1½ to 2 tons per square inch higher than would be expected from copper as pure as that employed by Clarebrough and his co-workers. Moreover, apart from the importance of composition brought out by Sato's work, it was clearly shown by H. Esser, H. Cornelius and W. Banck[9] that the amount of energy absorbed by steel during deformation was dependent on the carbon content, being only 0·26 per cent for electrolytic iron, but increasing with carbon content to about 5 per cent with 0·3 per cent carbon and 10 per cent with 0·8 per cent carbon. As Esser pointed out, it is not admissible to refer to the energy absorbed by any material during deformation without strictly specifying the composition.

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Sulphur-Impregnated Sintered Iron

DURING the last war there was a rapid development in the use of sintered iron powder as an anti-friction metal. Advantage was taken of its porosity to impregnate it with oil, paraffin wax, graphite, lead, synthetic resins or other materials in the hope of improving its properties as a bearing metal or as an anti-friction material in other applications. In a paper by G. Maassen[1] claims are put forward for the advantages of sintered iron impregnated with sulphur. As is well-known, sulphur melts to form a mobile liquid, which, with rise of temperature, becomes viscous and then, at about 400 deg. Cent., is again mobile. The impregnation must therefore be done at about 120 deg. or 400 deg. Cent. The amount of sulphur absorbed is controlled by the porosity of the iron. As a result of the filling of the pores with sulphur an appreciable strengthening of the iron takes place. The Brinell hardness of a sintered iron compact was raised from 37 to 52 by impregnating it with 6 per cent of sulphur.

The action of sulphur in lubricants is attributed to the formation, on the running surface, of sulphide films, which prevent seizing and, as they wear away, are continuously reformed. Maassen explains the lubricating properties of sulphur-impregnated sintered iron in a bearing as being dependent first on the slightly emollient sulphur impregnated in the pores and, secondly, on the sulphide film already existing and continuously reformed during running. Comparative tests on different kinds of impregnated sintered iron were made in the K.W. Institute wear-testing machine, described by E. Siebel and R. Kobitzsch,[2] in which specimens were pressed against a revolving ring of nickel-chromium-molybdenum steel. A rubbing speed of 3·12m per second was used with adjustable surface pressures. Of all the dozen or more varieties of sintered iron bearing materials studied, the sulphur-impregnated sintered iron gave the best results. With lead, graphite, paraffin wax and other forms of impregnation investigated, damage to the steel surface occurred at pressures of 400kg per square centimetre or less. With sulphur impregnation there was negligible wear on the steel at a pressure of 700kg per square centimetre. Impregnation with a suspension of sulphur in paraffin wax gave inferior results, though soaking in paraffin wax after impregnation with sulphur did no harm and may have given better results. The highest loads and speeds permissible with sulphur-impregnated sintered iron were not reached in these experiments. Within the range of values attained, the coefficient of friction decreased with increase of pressure. The point at which seizing occurred was not reached.

The paper represents sulphur impregnation as a radical improvement on all other methods of enhancing the anti-friction properties of sintered iron. Advantages are claimed for sulphur-impregnated sintered iron in conditions of high load and/or high running speeds, high temperature in the bearing, continuous operation during which there is a risk of clogging of the pores, and in places where an otherwise suitable lubricant is not possible, e.g., when the influence of fat-dissolving materials has to be taken into account. Treatment to increase corrosion resistance may be applied to the sintered iron before sulphur impregnation.

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Titanium and Zirconium Production in Natal

THE mining of rutile, ilmenite and zircon on a property at Umgababa, 25 miles south of Durban, which is said to contain mineral deposits capable of yielding a profit of £35,000,000 over the next thirty years, is likely to be commenced in about four or five months' time. Rutile, or titanium oxide, is one of the most important sources of titanium, a metal which, in its refined form, is at present worth £14,000 per ton. Ilmenite, a titanic iron ore, also a source of titanium, is being used to replace zinc oxide and white lead in the pigment industry. Zircon, which is a zirconium silicate, is a refractory material employed in the manufacture of alloys.

The concern responsible for these discoveries, the Titanium Corporation of South Africa, has been prospecting between Karridene and Umkomaas for the past seven years. Its geologists report that the hill at Umgababa, now known as Ilmenite Hill, contains 2,000,000 tons of ilmenite, 200,000 tons of zircon and 100,000 tons of rutile. At first, the company expects to produce a total of 60,000 tons of these ores a year, but hopes to step this up to 100,000 tons annually.

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DEFENCE, 1953

Last December, Mr. Churchill announced in the House of Commons that in the financial year 1953–54 expenditure upon defence would be levelled off instead of rising still further, as had been originally envisaged under the programme started by the Labour Government. In fact, as is revealed by the Statement on Defence, 1953, issued last week, expenditure on defence will still be some £100 million higher during the coming financial year than in the present one. The main object of the modification of the original programme is, of course, to permit the engineering industry—which, above all others, is affected by it—to increase its rate of production for export and so help to solve this nation's continuing balance of payments problem. What is of more interest to engineers, therefore, than the total estimated expenditure of £1636·76 million is the reduction of expenditure on production, research and development from over £850 million in 1953–54 as originally planned to about £650 million, of which well over £100 million will be devoted to research. That reduction of expenditure will be all the more strongly felt by many firms in that it will not apply to certain kinds of equipment to the production of which super-priority has been assigned. Many engineering firms therefore are finding and will find that dates of delivery under defence contracts are being deferred, and that little pressure for delivery will be exerted where the need of the Services is not urgent or—a wise decision—where it can be foreseen that output could be readily expanded in an emergency. In consequence, the firms concerned, it is hoped, will be enabled to quote oversea buyers earlier delivery dates and thus be better placed to meet competition. The marked improvement in the supply of raw materials, particularly steel, should enhance that effect.

The diminished pressure for rapid rearmament is not without advantages in other ways than that of facilitating oversea trade. For there is no certainty at the present time how the armed Forces ought to be equipped. Weapons in particular are undergoing startling developments. That is why, in the words of the Statement, "we must avoid committing ourselves too deeply to equipment which will have to be replaced at heavy cost within a relatively short space of time." The mechanisms of war, its logistics, even perhaps its strategy and tactics are steadily becoming influenced by the development, for example, of guided rocket weapons and the use of atomic bombs and guns firing shells with atomic warheads. Not only does this country need to develop defences against such weapons. We cannot expect adequately to develop defence without learning also how to use those new weapons of attack. Nor without those weapons of attack can our Forces be regarded as adequately fitted to fight a modern war. In time of war those in charge of production are always faced by the dilemma whether to provide arms in quantity which may prove obsolescent in service or to choose a lesser flow of higher quality, more advanced material. But in peacetime—even so uneasy a peace as rules at present—the decision should surely be heavily weighted towards quality. For once the first crunch of the war is over, the nation more likely to prove successful in a longer struggle is that which has available, ready for production in quantity, designs of armaments more advanced than those of its adversary. But they must be ready for production! Thus, research should not solely be devoted to the development of improved armaments. In the last war many difficulties were encountered in raising armaments production quickly. One at least of those difficulties might be eliminated if the problems of mass production, largely by unskilled labour, began to be studied as each new prototype appeared and were not left to be solved, often unsatisfactorily, upon the factory floor after production was begun. Research into the productive methods applicable, beginning when a device was no further advanced than the prototype stage, might well be repaid by the rapidity with which a full production flow could be established in emergency.

Suggestions are sometimes made that the interests of the N.A.T.O. nations would be better served than at present if the U.S.A. alone became responsible for the provision and operation of certain arms, such, for example, as long-range bombers. But for our part we hope that any such suggestions will be resisted. Britain has commitments to the Commonwealth and elsewhere that are not shared by the U.S.A. Furthermore, unless bombers are developed in this country the development of means of defence against them will be handicapped. If necessary, we hold, Britain should be fully armed to stand alone in defence against a third nation. Twice in this century the U.S.A. has taken many months to make up its mind to enter a war. It might do so again! What could much more usefully be further pressed is international standardisation, not so much, perhaps, of armaments themselves, of aircraft, guns, tanks, lorries, electronic equipment, &c., as of certain basic structural elements such as screw threads, limits and fits, calibres of small arms, engineering symbols, and so forth, so that parts and assemblies made to the same designs in different countries would be fully interchangeable. For it is a positive advantage in peacetime that alternative designs of aircraft, guns, tanks and other equipment should be developed in different countries. Not only is it valuable that there should be stimulating competition in their development, but wars have to be fought over many different oceans and terrain, and under many different climates. The best mechanical equipment for fighting a war in temperate Europe may be far from well suited for use in Arctic snows or the heat of the desert.

GAS TURBINE LOCOMOTIVE WORKING

In the whole history of transport there can be few, if any, forms of propulsion that have been developed more rapidly than the gas turbine. For railway use it has the attraction of an optimum thermal efficiency nearly two and a half times that of a normal steam locomotive, and of a high power-weight ratio; and very soon after the conclusion of the second world war the Great Western Railway, on the recommendation of its last chief mechanical engineer, Mr. F. W. Hawksworth, embarked upon an experiment that has attracted world-wide interest. Mr. A. W. J. Dymond, as one of Mr. Hawksworth's assistants, was fortunate enough to be closely associated with this project from the very outset, and on Wednesday of last week, February 18th, in presenting his paper to the Institution of Locomotive Engineers, he described it as something of an interim report. This paper, which we printed in part last week, and which is concluded in this week's issue, is a frank and factual account of the difficulties, disappointments, and the undoubted successes that have so far been experienced with the Brown-Boveri and with the Metropolitan-Vickers locomotives, though in presenting it Mr. Dymond emphasised that the general design of the locomotive is now six years old, and that six years is a very long period in the history of the gas turbine itself. Reading the paper, and listening to the discussion following it on February 18th, one gained the impression that the various troubles that have been encountered, particularly with the Brown-Boveri machine, and which have kept that

locomotive out of traffic for quite lengthy periods, are no more than incidental and are in no way *per se* likely to jeopardise the development of the gas turbine as a form of railway motive power. Both the locomotive building firms, and no less the railway engineers, are to be warmly congratulated upon the way in which the gas turbine has been adapted to produce high-powered locomotives within the numerous limitations imposed upon space and weight, particularly within the restricted loading gauge of British Railways.

On paper the Metropolitan-Vickers machine, No. 18100, is by far the most powerful express passenger locomotive that has yet run on British metals. It has a nominal tractive effort of some 60,000 lb—that is about 50 per cent greater than that of the various class "8P" steam engines of British Railways—and yet the total weight in working order is only 129½ tons. By comparison the weight of the class "8P" steam express passenger engines, including tenders, range from the 135¾ tons of a Western Region "King" to the 164½ tons of an ex-L.N.E.R. "A1 Pacific." No comparison could stress more forcibly than this the advantage of the gas turbine, so far as the power-weight ratio is concerned — more particularly as the entire weight of No. 18100 is available for adhesion. It is clear, too, that the nominal tractive power of this locomotive is no mere theoretical ideal. Mr. Dymond himself and speakers in the discussion on February 18th gave evidence of its exceptional haulage capacity, in comparison with that of existing steam locomotives. Though that capacity is no more than one could reasonably expect, the point for emphasis seems to be that its increased capacity is obtained from a locomotive weighing no more than 129½ tons all up. In this respect the gas turbine scores heavily over the diesel-electric, though when it finally comes down to basic considerations it is the cash value of the power developed that counts most. On January 24th last, in a lecture to the Graduates' Section of the Institution of Mechanical Engineers, Mr. R. A. Riddles quoted some interesting figures of fuel costs for different forms of British railway motive power. The cheapest was the diesel-electric at 1·05d. per drawbar horsepower-hour, as represented by the Southern locomotive No. 10202 on the Waterloo-Exeter run; this was closely followed by steam, at 1·18d. represented by the Great Western "Castle" 4–6–0, and the straight electric at 1·28d.—the Southern No. 20003 on the Newhaven boat trains. The Brown-Boveri gas turbine working, like the "Castle," on the Paddington-Plymouth service, showed a cost as high as 2·27d. per drawbar horsepower-hour. On this particular service the thermal efficiency of the gas turbine, fuel to drawbar, worked out at no more than 6·6 per cent, against 5·5 per cent for steam, and even though the Swiss locomotive uses residual fuel the relatively high cost of this fuel, compared even with the present cost of locomotive coal, militates against the gas turbine.

In his paper Mr. Dymond frankly confesses that the operating costs on the usual "per mile" basis for fuel alone strike a somewhat disheartening note; but while these costs, compared with the optimum overall efficiency of a gas turbine, are disappointing they arise from an inherent characteristic of railway service—and particularly British railway service—that one can hardly expect to see changed. While a relatively high tractive effort is needed for starting, for surmounting heavy gradients, and for regaining speed after incidental slowings the average demand for power is relatively low, and in the gas turbine, this results in the locomotive running for long periods at well below its range of maximum thermal efficiency. As Sir William Stanier said in a notable contribution to the discussion, until the load-efficiency characteristic of the gas turbine can be made to correspond in some way to that of the steam locomotive, on a higher plane throughout, commensurate with the optimum efficiencies of the two machines, the potentialities of the gas turbine in railway service will not be realised. We feel, however, that in quoting certain comparative details of running Mr. Dymond did less than justice to the fine steam locomotives of Swindon parentage, and he was duly and good-naturedly called to account for it by Sir William and other speakers. But what was a little surprising to us was that the protagonists of electric and diesel-electric traction were almost silent in the discussion, while other participants went so far as to suggest the entire elimination of the electric transmission in future experimental gas turbine locomotives. In view of present fuel costs the building in this country of a coal-fired gas turbine locomotive is an experiment that will be watched with the greatest interest. All in all February 18th proved a notable occasion for the Institution of Locomotive Engineers. While one could hardly expect to deduce, either from the paper itself or from the discussion, what the future holds for gas turbine propulsion on railways, it is no exaggeration to say that the eyes of the railway world are upon locomotives 18000 and 18100, and the many who think nostalgically of the Great Western Railway may take pride that this notable piece of British pioneer work originated at Swindon.

Obituary

H. B. FERGUSSON

We regret to record the death of Mr. Hugh Boscawen Fergusson, M.I.Mech.E., M.I.N.A., which occurred in London on Friday last, February 20th. Mr. Fergusson was the senior director of G. A. Harvey and Co. (London), Ltd.

Mr. Fergusson studied mining engineering at the Royal School of Mines, Freiberg, Germany, and was subsequently in partnership with his father in a consulting engineering practice in Vancouver. He joined the Royal Volunteer Engineers in 1914 and in the early part of the first world war was in charge of a contingent to North Russia which was engaged on the construction of the Murmansk Railway. In 1916, Mr. Fergusson was appointed works manager of the Royal Ordnance Factory at Gretna, and after the war he spent a year in Cologne as chief technical adviser to the British Military Governor. The subsequent years of Mr. Fergusson's career were spent in Spain, as consulting engineer on various hydro-electric and railway electrification projects, and in South America, as chief agent for railway construction.

Mr. Fergusson joined G. A. Harvey and Co. (London), Ltd., in July, 1933, as manager of the heavy construction department, and was appointed a director in 1938. He was a member of the Institution of Mechanical Engineers, the Institution of Naval Architects, and of the Engineering Institute of Canada.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

"THE CAPITALS, LTD."

Sir,—I am surprised that no one has so far suggested the reason for "The Capitals, Ltd." gaining five minutes between Prestonpans and Edinburgh, as reported by Mr. Livesay, in the issue for December 12th. The existence of the recovery margin of five minutes between Longniddry and Portobello would account for this.

The introduction of these margins has been one of the apparently less desirable imports of recent years from across the Atlantic and their provision now even extends to all-stations trains running over the 30-mile stretch between Saltburn and Darlington. When provided at the end of a run, the chances of a right-time arrival are increased, but last summer there were three recovery margins for "The Capitals Ltd," totalling fourteen minutes in all. When an engine is behaving well a driver is faced with two alternatives on a non-stop run when there are intermediate recovery margins. Either he runs up to time and then, in order to avoid the risk of being brought to a dead stand, crawls over the easily timed sections, or, alternatively, runs slightly behind time over the various stages so that the recovery margin is adsorbed in the normal running. The latter method, which involves more consistent running, encourages slack driving elsewhere when there are no recovery margins.

As the recovery margins are only provided at the approach to busy junctions, such as Doncaster and Newcastle, their application to all expresses necessarily leads to the tracks in the vicinity being occupied longer owing to the lower speed, which would seem to be an additional disadvantage.

The most amazing mystery on Mr. Livesay's journey has, however, gone unnoticed. After taking nearly three hours to cover the 105¼ miles to Grantham, he was then suddenly whisked over the 82¾ miles to York in fourteen minutes, at an average speed of no less than 355 m.p.h.! The passing time at Grantham is given as 12.27, which is presumably in mistake for 11.27.

P. W. B. Semmens

Middlesbrough, Yorks, February 10th.

[The speed was even greater than our correspondent notes. Going north the train passed Grantham at 12.27 p.m. and reached Doncaster at 12.17½ p.m.! The editors and printers as well as Mr. Livesay must be held responsible for propelling the train at so reckless a speed that, had it been maintained over the rest of the journey, Mr. Livesay might have arrived in Edinburgh in time for breakfast.—Ed., The E.]

EAST COAST FLOODS

Sir,—In all that has appeared in print about the floods of January 31st–February 1st, I have seen no comment on one point which seems to me most important.

The coast and rivers lines are girt by reclamation banks each of great length. Frequently there is for miles no cross wall from this bank to the inland flood contour. Such cross walls would act as bulkheads to subdivide the floodable area—their absence greatly increases the difficulty in repairing breaches. Of course, the construction of such bulkhead banks would be costly, but capital expenditure and the necessary occasional maintenance charges would be more than repaid by the increased security accorded

to the land—particularly in cases where the construction of houses and bungalows has been allowed.

We must now face enormous capital expenditure on repairs to and raising of flood banks and on the restoration of house and agricultural property. We should also ensure that the floodable area is subdivided so that the risk of a repetition of the disaster is lessened.

L. S. B. SIMEON

Harwich, February 21st.

LIBRARY SERVICE FOR INDUSTRY

SIR,—I have read with interest the article on this subject from Mr. K. J. Rider, of the Birmingham Technical Library (your issue of February 13th), and I sympathise with his efforts to ensure that industry receives adequate library service. A point to which he makes repeated reference is the answering of inquiries received in libraries, including the necessity for checking with other libraries and sources of information. In this matter he leaves one aspect out of account, namely, the extent to which industrial inquiries can be handled purely by librarians and from library sources.

Many inquiries can suitably be treated in this way: compositions of materials, trade names, sources of supply and kindred matters. There are, however, many inquiries to which answers from this point of view are useless: what is required is "know-how," i.e. practical industrial or laboratory experience of the problem. Many an apparently simple problem can be offered to a librarian, who proceeds quite efficiently to offer literature or literature extracts in his answer, with a result which is often of little or no assistance because it is literary and academic, lacking the essential detail which only the experienced scientist or technologist can provide. I do not belittle the value of libraries and librarians to industry, and I have for many years been very active in forwarding their interests, but I am more and more convinced by long experience that the help that the librarian can give must be clearly delimited. I am myself a science graduate, and our information department is backed by an efficient library, but whenever this department or the library receives an inquiry from industry we are careful (even if a good deal of literature on the subject is available), to consider whether we should call in the assistance of our liaison and technical service department (staffed by scientists with industrial experience) or of our research colleagues: after an experience covering many thousands of inquiries I am in no doubt of the wisdom of this attitude. I think that public librarians, and in general librarians without immediate access to colleagues with "know-how," would be well advised to couple any answers they give with advice to the inquirer to make contact with an appropriate industrial research association, with the Department of Scientific and Industrial Research, or with any other appropriate scientific or technical body. This is particularly true of small firms having no technical resources of their own: to such firms the essential point of an answer to an inquiry is that it shall be put in their own homely, technical language, which librarians cannot know. Incidentally, this is the kind of help which guides such firms to use scientific and technical literature.

From considerations of space I refrain from developing this theme at further length. There is, however, one other point in Mr. Rider's article which calls for comment. Speaking (page 253, column 1) of firms who are members of research associations, he says: "But unless the research association is near at hand, firms cannot rely on its library for day-to-day needs. For these they can turn to their local public libraries." We have continuous evidence that many such firms do rely on their research association for day-to-day needs. We receive telephone requests for literature from members in distant parts of this island (including Birmingham) quite frequently, and our post-bag is an eloquent testimony to the day-to-day needs of our members. Public libraries in some large industrial centres could help to take some of the load off the special libraries for a good deal of the more conventional scientific and technical literature, but the main burden will, I think, continue to fall on the special libraries, which are necessarily better staffed and equipped for service in this field.

I do not, however, wish to close this letter on an unfriendly note. As far as the importance of adequate provision of literature to industry is concerned, I am wholly sympathetic to Mr. Rider's endeavours: more power to his elbow.

B. FULLMAN
Chief Information Officer
The British Non-Ferrous Metals Research Association,
London, N.W.1.
February 18th.

The James Clayton Prize

THE Institution of Mechanical Engineers has divided the 1952 James Clayton Prize, valued at £1610, between Professor H. W. Swift, M.A., D.Sc. (Eng.), M.I.Mech.E., and Mr. H. Hillier, O.B.E., M.I.Mech.E. The award to Mr. Hillier was made for his contributions to marine engineering, particularly in the field of auxiliary machinery, communicated in part in a paper submitted to the Institution during 1952. This paper, "Scale Formation in Sea Water Distilling Plants and its Prevention," was given by Mr. Hillier at a meeting on January 30, 1953. Professor H. W. Swift received the prize for his contributions to mechanical engineering in the fields of education, lubrication and experimental research, communicated in part in a paper delivered to the Institution on December 5, 1952. This was a joint paper by Professor Swift and Dr. S. Y. Chung, entitled "An Experimental Investigation into the Redrawing of Cylindrical Shells." The prizes were awarded at a general meeting of the Institution in London on Friday last.

Literature

SHORT NOTICES

Presswork and Presses. By J. A. Grainger. Brighton: Machinery Publishing Company, Ltd., National House, West Street. Price 55s.—Few branches of production engineering present more problems or have made greater advances in technique in recent years than the pressworking of metals. With this in mind, Mr. Grainger has drawn upon his extensive experience to provide a work of reference for the use of all who are concerned with pressing sheet metals from the design and manufacture of the tools to the machines on which they are used, particularly in the fields of light and medium presswork.

The opening chapters of the book deal with tooling and blanking; bending and forming; combination tools; compound tools; follow-on die work; shallow drawn work; and deep drawing. In each case the design of the tool is described in detail; its applications and use, the type of machine best suited for its operation, &c. Various types of presses are then dealt with in some detail—their operation, maintenance and setting—followed by a chapter on ancillary equipment for trimming, beading and guillotine cutting. Many economies can be made and difficulties avoided in a works by tool standardisation, and a chapter on standardisation contains useful guidance on the making of standard press charts, adaptors to give interchangeability of tools and presses, and suggested standards of dies, bolsters, &c. A section on the materials used in presswork, which takes into account their defects as well as some of the difficulties encountered in their production, concludes with some notes on new materials covering possible developments and future needs. In his final chapter on the future trend the author discusses the ways and means by which improvements can be made to increase the efficiency of the industry, particularly in respect of press design and construction.

The book provides a mass of up-to-date information presented in a clear, concise way which will appeal to all readers. The one serious criticism we have to make is the very poor quality of the drawings reproduced in the book. Many of the drawings are reduced considerably in size and the difficulty in reading them is accentuated by the innumerable lead lines which have been superimposed for reference purposes. Despite this criticism, students will find this book a valuable guide to modern practice and methods, whilst experienced designers and makers of press tools will find it a comprehensive work of reference well worth having ready to hand in their libraries.

Steelwork in Building By W. B. Scott. London: E. and F. N. Spon, Ltd., 22, Henrietta Street, W.C.2. Price 25s.—The sub-title of this volume is "A Commentary on the British Standard Specification on the Use of Structural Steel in Building printed with the Specification." The specification in question is B.S. 449 : 1948, and the general plan of the book has been to present each clause of the specification with the related comments next to it. It is pointed out in the foreword by Mr. V. H. Lawton that the specification is a great advance on its predecessors and its requirements necessitate changes in certain methods of design used hitherto. Under the new standard three methods of design are permitted—"simple," "semi-rigid" and "fully rigid," the last method permitting designs to be made using the plastic theory. The author's comments explain and amplify the reasons for the various clauses of the specification and give guidance in their application to particular design problems. The specification covers all the various aspects of steel construction. Further information is given in appendices concerned with, for instance, high tensile steel, and in numerous design tables incorporated with various sections of the author's commentary.

BOOKS RECEIVED

Rocket Propulsion. By Eric Burgess. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 21s.

Mechanical Biology. By P. H. Francis. London: Mitre Press, Mitre Chambers, Mitre Street, E.C.3. Price 30s.

Modern Motor-Cars. By K. C. Hunt. London: Temple Press, Ltd., Bowling Green Lane, E.C.1 Price 9s. 6d.

Major Faults on Power Systems. By A. G. Lyle. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.

Part-Time Teaching. By F. W. Kellaway. London: C. Bell and Sons, Ltd., York House, Portugal Street, W.C.2. Price 7s. 6d.

Essential of Fluid Dynamics. By Ludwig Prandtl. Glasgow: Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 35s.

Substation Practice. Second edition. By T. H. Carr. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 55s.

Boiler House Practice. Third edition. By E. Pull. Surrey: Technical Press, Ltd., Gloucester Road, Kingston Hill. Price 12s. 6d.

Tensors in Electrical Machine Theory. By W. J. Gibbs. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

D.C. and A.C. Machines. By Michael Liwschitz-Garik. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 52s. 6d.

British War Production. By M. M. Postan. London: H.M. Stationery Office, Atlantic House, Holborn Viaduct, E.C.1. Price 32s. 6d.

Chemical Engineering Techniques. By B. E. Lauer and R. F. Heckman. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 48s.

Teach Yourself Mechanical Engineering: Workshop Practice. By A. E. Peatfield. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 6s.

Handbook on Mechanical Stokers for Shell Boilers. London: National Coal Board, Production Dept., Hobart House, Grosvenor Place, S.W.1. Price 15s (to educational establishments and students 11s. 6d).

The Testing of Concrete Mixers

By R. H. H. KIRKHAM, B.Sc., Ph.D., A.M.I.C.E.*

No. III—(*Continued from page 288, February 20th*)

A COMPARISON OF PERFORMANCE OF CONCRETE MIXERS

A commonly used mixer is the non-tilting machine, sometimes referred to as the free-fall or rotating-drum type, and it was considered desirable to compare its performance with that of the tilting-drum and open-pan mixers. Tests have thus been carried out to measure the efficiency of several mixers of these three kinds when mixing lean, dry concrete ; the capacities of the mixers were all less than ½ cubic yard.

Method of Test

THE performance of non-tilting, tilting-drum and open-pan machines was assessed by determining the proportions of eight samples of concrete withdrawn during the discharge of each of several batches of concrete.[1] The batches were mixed for times ranging from 0 to 300 seconds so that the minimum time required for mixing could be determined and the uniformity of the mixture after this time could be measured both within one batch and from batch to batch.

For the main series of tests the performance of three non-tilting mixers, two tilting-drum and two open-pan mixers was measured, using a mix typical of that likely to be used in road construction. The proportions were 1 : 2½ : 5 by weight with a water/cement ratio of 0·6 by weight using normal Portland cement and a river gravel of ¾in maximum size and a river sand : the aggregates were thoroughly dried before use. The size of the mixes was chosen so that each mixer was loaded to deliver an amount of concrete which would be equal to its rated capacity when fully compacted (density 144 lb per cubic foot). All of the non-tilting and one of the tilting mixers were fitted with power loaders and water-measuring tanks, and one of the open-pan machines had a power loader. When they were fitted the water-measuring tanks were carefully calibrated and they and the power loaders were used to charge the mixers. Neither of the pan mixers incorporated a water-measuring tank and a simple tank was fixed above the mixer into which the water for each test was weighed. The details of the tests are given in Table IV.

For each mixer the sequence of operations was chosen to follow as far as possible the sequence most likely to be used in practice except that, for those machines which did not incorporate a power loader, the materials were loaded into the mixing drum while stationary in order to obtain comparable experimental conditions. For the non-tilting mixers the flow of water was started first, and then the dry materials were loaded, the mixing time being measured from the instant at which all the batch was in the drum. For the 7T mixer when the drum was tilted into the loading position the water was introduced automatically and was followed by the solid materials ; the mixing time was measured from the instant the drum was returned to the mixing position. For the 7 cubic foot pan mixer the dry materials were loaded into the pan first in order to avoid loss of water through the discharge door, and the water was introduced immediately afterwards, the mixing time being measured from the instant all the water was delivered. The solid materials were batched by weight and loaded in a standard manner into the loading skip. For the 3½T and 9 cubic foot pan mixers the materials were loaded in the same manner into the stationary drum, the water was added and the mixer started. The mixing time was measured from the time of starting the mixer. In all the tests the materials were loaded into a clean, dry drum.

In order to provide a standard with which the results could be compared the method of analysis as described in No. I was used to assess the uniformity of concrete mixed as thoroughly as possible by hand as described in No. II. Five batches were mixed, all of the same proportions as those used in the tests of the mixers, and the proportions of eight samples from each batch were estimated.

Subsidiary tests were also carried out to investigate particular difficulties associated with each type of mixer. During the tests on the 7NT mixer as much as possible of the material remaining in the drum after discharge was removed and a sample was analysed by the same method as that used for the eight samples from the discharged concrete. Two extra tests were carried out on the 7T mixer to examine the distribution of materials in the drum. For these tests the drum was loaded while stationary in the vertical position ; in one the cement was placed at the bottom followed by the sand and gravel and, in the other, the order of loading was reversed, the gravel being at the bottom and the cement at the top. The materials and mix proportions were the same as those used in the main series and mixing was commenced by swinging the drum into the charging position to add the water. The mixing time, measured from the instant the drum was swung into the mixing position, was 180 seconds for both these tests.

To investigate the distribution of the materials in the pan mixers, tests were carried out on two 1 cubic foot laboratory machines in one of which the mixing star was rotated 1·6 times as fast as in the other. The materials, mix proportions and method of loading were the same as those used for the 9 cubic foot mixer but, at the end of the mixing time, the pan was stopped and the samples were taken from it. The depth of the mixed concrete in the pan was about 4in, and four samples were taken from the top 2in and four from the bottom, one of each set being from the middle and the other three from the edge of the pan.

The Uniformity of the Concrete Within One Batch and the Time Required for Mixing

The standard deviations of the water/cement, sand/cement and gravel/cement ratios given by the eight samples from each batch are shown for all the tests on the seven mixers in Figs. 13, 14 and 15, respectively, the results being arranged so that the pan and tilting-drum mixers can each be compared separately with the non-tilting machines. There was considerable scatter of the results for each mixer, and the amount of variation to be expected in one batch was therefore calculated from all the results after the concrete had been mixed until prolonging the mixing gave no further improvement in uniformity. In this way the standard deviation of the water/cement ratio for the non-tilting mixers was found to vary

Table IV—Details of the Tests

Type	Rated capacity	Total weight of one batch (lb)	Remarks
	Main Series		
Non-tilting	7 cubic feet	1019	Power loader and water-measuring tank used
	500 litre (12 cubic feet)	1820	Power loader and water-measuring tank used
	14 cubic feet	2038	Power loader and water-measuring tank used
Tilting	3½ cubic feet	509	Drum loaded in mixing position while stationary
	7 cubic feet	1019	Power loader and water-measuring tank used
Pan	7 cubic feet	1019	Power loader used
	375 litre (9 cubic feet)	1274	Drum loaded while stationary
	Subsidiary Tests		
Tilting	7 cubic feet	1019	Drum loaded in vertical position while stationary
Pan	1 cubic feet	150	Drum loaded while stationary
	50 litre (1·2 cubic feet)	187	Drum loaded while stationary

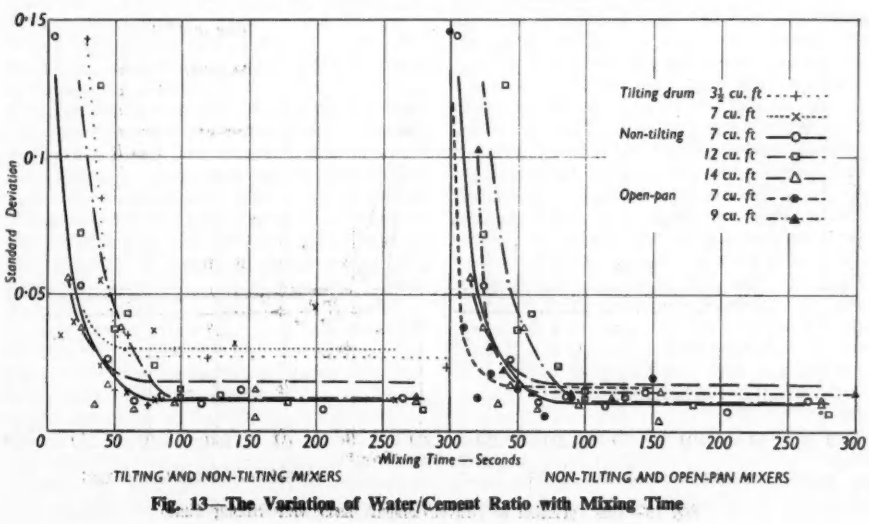

Fig. 13—The Variation of Water/Cement Ratio with Mixing Time

* Road Research Laboratory.

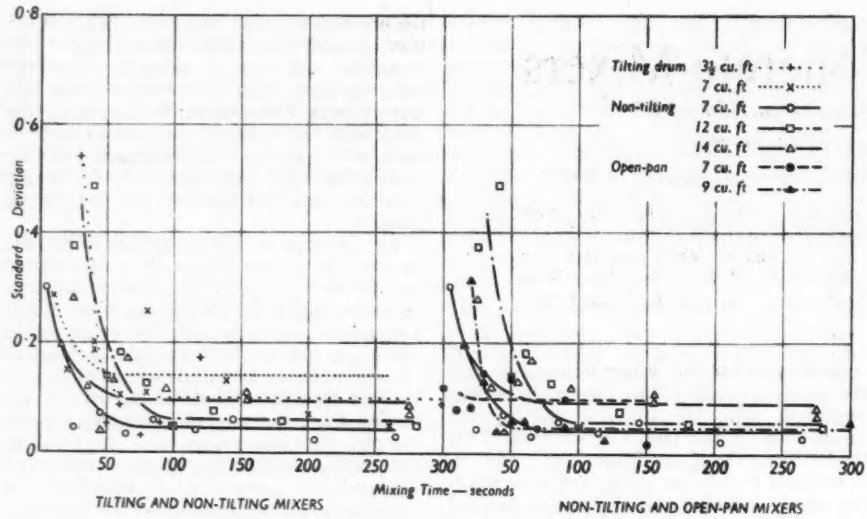

Fig. 14—The Variation of Sand/Cement Ratio with Mixing Time

from 0·012 to 0·018, the 14NT producing slightly more variable concrete than the 7NT or 12NT. The standard deviation for the two pan mixers was in the same range so that any difference between them was less than the difference between mixers of the same type. For the two tilting-drum mixers, however, the standard deviation of the water/cement ratio was much higher (0·027 and 0·030), and it can be concluded that the water and cement are not so well mixed in this type of mixer as in the other two.

There were also differences in the time required to produce the most uniform water/cement ratio of which each of the mixers was capable. In view of the scatter of the results it was not possible to determine precisely the minimum times required for mixing. In any case the time required for mixing by different mixers can only be compared by considering also the quality of the concrete produced by each mixer, and it was considered preferable to draw average curves through the points which enable the uniformity achieved by different mixers to be compared after any mixing time. From these curves it appeared that mixing was slower in the 12NT than in the 7NT or 14NT and faster in the 7 cubic foot pan mixer than in the 9 cubic foot, which needed about the same time as the 7NT and 14NT. It seems likely that the shortest mixing times will be given by the open-pan type of mixer, but the best non-tilting machines are likely to have mixing times as short as those of some pan mixers. The time required for mixing in the tilting-drum mixer was not short enough for there to be any advantage in using this type even if the quality of the concrete was not important.

The differences in the uniformity of the sand/cement ratio were similar to those of the water/cement ratio, but the difference between the tilting and non-tilting mixers was not so marked. The standard deviation of the gravel/cement ratio, after prolonging the mixing until no further reduction was obtained, was very similar for six of the mixers, only the 3½T giving a more variable mix. This greater variability can probably be attributed to the relatively small drum, and it seems unlikely that the coarse aggregate will be uniformly distributed in these small machines. The time required for mixing the gravel was similar for the tilting and non-tilting machines, but it was noticeable that the gravel was mixed with the cement more quickly by the pan-type mixer.

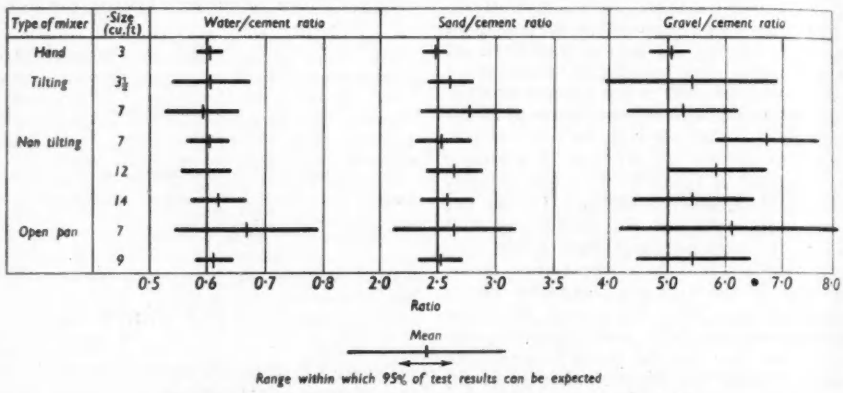

Fig. 16—The Limits Within Which 95 Per Cent of Test Results Can Be Expected

The Average Quality of the Concrete

The efficiency of the machines depends not only on the variation within one batch, but also on the variation between batches. The results were therefore analysed statistically for all those batches mixed for periods greater than the minimum beyond which further mixing gave no increase in uniformity. From the total standard deviation of the water/cement, sand/cement and gravel/cement ratios the limits were calculated within which 95 per cent of test results could be expected to fall ; they are given in Fig. 16, together with the limits for similar concrete thoroughly mixed by hand. This method of presenting the results was considered the most satisfactory since in practice it is becoming customary to permit the results of tests on a limited number of specimens to fall below the minimum required by the specification. For the limits given here it would be expected that 2½ per cent of the test results would be below the specified minimum.

The results show that none of the mixers produces such uniform concrete as that which can be produced by very thorough hand mixing. The water/cement ratio of the materials mixed in the 9 cubic foot open-pan mixer was the most uniform of the mechanically mixed concretes, the total variation being slightly less than that given by the 7, 12 and 14NT machines (Fig. 16). The average mix proportions and the results of the analysis of variance are given in Table V, from which it can be seen that, although the variation within batches was similar for the two types, the variation between batches for the 9 cubic foot pan mixer was remarkably small, resulting in a reduction in the total variation. When the tilting-drum mixers were compared with the non-tilting machines the variation of the water/cement ratio was significantly greater, as was found when comparing the variability within a batch. The most surprising result was given by the 7 cubic foot pan mixer, which gave a large total variation in the water/cement ratio although the variation within a batch was small, this being the only mixer for which the variation between batches was much greater than that within batches. This was considered to be due to the difficulty of loading the cement into this mixer

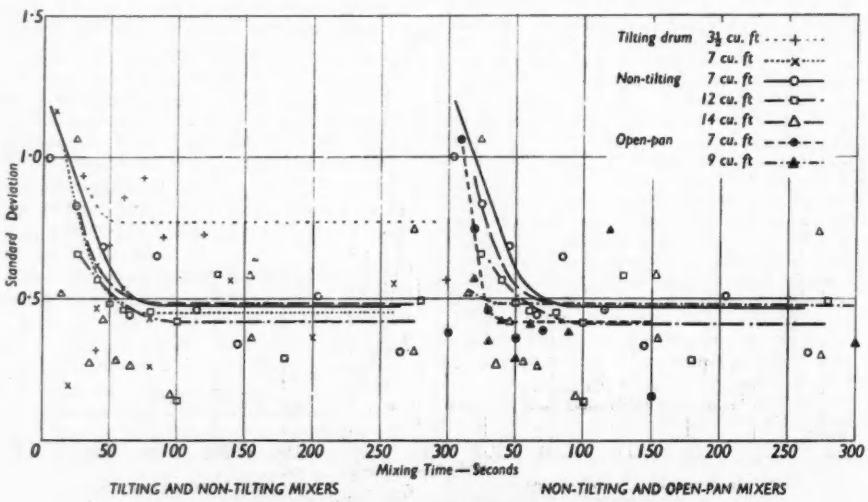

Fig. 15—The Variation of Gravel/Cement Ratio with Mixing Time

without loss as discussed in a later section.

The variation of the sand/cement ratio of the concrete from all the mixers was also greater than that of the hand-mixed concrete, but there was less difference between the machines. In only the 7T and the 7 cubic foot pan mixers was the sand/cement ratio significantly more variable than in any of the others. In both these mixers there was a very large variation between batches, which explains the large total variation. In the other mixers those with small variations within a batch often had larger variations between batches than those with less uniformity in the batch, and the total variation was very similar for them all.

The gravel/cement ratio of the hand-mixed concrete was also much more uniform than that of any of the concrete mixed in the machines. Of the mechanically mixed concretes those from the 7 cubic foot pan mixer and the 3½T had particularly large variations. For the former the total variation was mainly due to a large batch-to-batch variability, while for the latter the variation between batches was insignificant compared with that within one batch, and the variation has been attributed to the difficulty of mixing the aggregate in the small drum. All the other mixers gave concrete with about the same uniformity in the gravel/cement ratio, but there was considerable variation in the average values, that for the 7NT being particularly high.

These results are similar to those obtained by Nycander[2] who showed that a pan mixer of the same kind as the 9 cubic foot machine used in these tests gave more uniform mixing than a non-tilting mixer which was more efficient than tilting-drum machines. The variations shown by the 7 cubic foot pan mixer, however, make it impossible to regard this type as being consistently more efficient than the others.

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[1] Kirkham, R. H. H., "The Testing of Concrete Mixers, Part I: Method of Test." (Pages 232-235 *ante*).

[2] Nycander, P., "Testing of Concrete Mixers," *Statens Provningsanstalt. Middelande*, 100, 1947.

(*To be continued*)

Fretting Corrosion

INSTITUTION OF MECHANICAL ENGINEERS

AT a meeting of the Institution of Mechanical Engineers, held in London last Friday, February 20th, a paper, of which a summary follows, was read.

AN INVESTIGATION OF FRETTING CORROSION

By K. H. R. WRIGHT, Ph.D.*

In this paper a series of experiments is described on the subject of fretting corrosion, an expression used to describe the surface damage occurring between two closely fitting surfaces subject to slight vibrational movement. The emphasis of the research has been placed upon obtaining quantitative measurements of the degree of fretting damage, and it has been shown that considerable reproducibility can be obtained, thus making it possible to correlate this measurement with such variables as total number of oscillations, load, or atmospheric humidity. Humidity variations have been shown to have a pronounced effect on both the form and total amount of damage, and this probably accounts for the large discrepancies between the observations obtained by different workers.

Although most of the measurements have been made using lapped carbon steel specimens, some results were obtained with other materials such as chromium, nickel, and gold. Nickel-plating has been advocated as an anti-fretting surface, but the experiments clearly show this to be ineffective, unless it can be assumed that the nickel-plating has the additional effect of reducing the slip between the two surfaces.

The use of lubricated phosphated surfaces can be strongly recommended for inhibiting fretting corrosion, from the results obtained with this form of surface preparation rubbing against a steel flat.

Additional experiments have been carried out with carbon steel surfaces to establish the significance of the absorption and diffusivity of oxygen in surrounding liquid media.

DISCUSSION

Dr. F. T. Barwell said that the work of Tomlinson, Thorpe and Gough at the National Physical Laboratory, to which the present author had referred, had put this country in the leading position in the study of fretting. He thought that the present paper could be accepted as an indication that that lead was being maintained. However, in the interim period some work had been done in America, and when on a visit to that country just over a year ago he noticed that an interesting experiment was being carried out at the laboratories of the National Advisory Council for Aeronautics at Cleveland, Ohio. This experiment enabled the actual process of fretting to be watched, and, because it was always a good thing to base one's thinking on what could be actually seen and felt, he thought that it would provide a good starting point for the discussion that evening. He therefore handed over the task of opening the discussion to Mr. Godfrey, who used as his medium of addressing the meeting a film which had been obtained through the good offices of Mr. Chisholm, of the U.K. Scientific Mission in Washington. After the showing of the film, Dr. Barwell added that perhaps the most striking feature of the film was the evidence of the presence of two quite distinct forms of oxide debris. That was in line with the evidence reported in the present paper. In marked contrast, however, was the emphasis placed by the two authors on the role of oxidation during fretting. Mr. Godfrey relied on his demonstration to assert that fretting was primarily a frictional phenomenon, oxidation being of secondary importance; Dr. Wright, on the other hand, had obtained experimental evidence of the effect of the environment on the amount of fretting.

The strength of Dr. Wright's paper lay in the fact that he was the first investigator to succeed in putting the subject on a sound quantitative basis, since he had shown conclusively that whereas the inception of fretting might be purely mechanical in character, its damaging nature was largely due to the presence of oxidised material. The quantitative nature of his experiments made possible for the first time the unbiased assessment of the benefit of remedial measures. Two practical proposals to minimise fretting emerged from the present experiments, namely, the provision of a non-metallic surface film coupled with lubrication. The nature of the phosphating process led to the hope that these promising laboratory tests would be repeated in the circumstances of practice. In one respect, Dr. Wright and Mr. Godfrey were in complete agreement, namely, in stating that fretting corrosion was a particular manifestation of a more general form of wear. The effect of environment and the formation of different oxides and hydroxides might have an important bearing on the whole range of frictional and wear phenomena and might explain such unrelated behaviour as the variation of friction between wheels and rails in different weather conditions.

Dr. D. Clayton had a few questions to ask the author. The first, which had in part been answered by Mr. Godfrey, related to the particles that were pulled out of the surface in the early stages. The author said that they were larger than atoms, and it seemed that if they oxidised the oxidation must be on the surface of the particles, so that there would be plain iron inside an oxide envelope. Mr. Godfrey's film showed a number of stages of breakdown, which largely answered that question. It was difficult to believe, if the particles were more than atomic in size, that the oxidation could occur so very rapidly as had commonly been assumed, notably in Dr. Tomlinson's early work and particularly his paper in 1927 or 1928 on the fretting action. The next question related to the slip, which in the author's work had been maintained at 0·001in. The author said that that had been set rather large, but had it been deliberately set large so as to avoid some of the complications which Tomlinson, Thorpe and Gough encountered in maintaining their slip? They had tried to maintain a very small slip, of about 10^{-7}in, and found it very difficult to maintain, presumably due to the varying adhesion and probably also to varying friction. Had the 0·001in slip been chosen partly to overcome that difficulty? It was to be expected from all that had been said that the amount of fretting would be dependent on the tangential force, and that brought in the coefficient of friction. It was surprising that the author did not introduce more values of the coefficient of friction. He might have given greater emphasis to friction as an important force in this phenomenon. Lubricants would reduce the oxygen and the moisture that got to the surface, but they would also normally reduce the friction at the same time. Another question related to the closeness of the surfaces. The gap would be extremely small and, therefore, the circulation of oxygen and moisture would be very low on that account. Had the surfaces been conditioned so far as the adsorbed layers of oxygen and moisture were concerned before the tests at the different humidities?

There was obviously a considerable similarity between the action in fretting and the action in continuous sliding, as the author had mentioned in introducing the paper, but Dr. Clayton thought he was right in saying that the oscillatory motion increased the friction force and the adhesion between the surfaces, so that the damage would be greater under oscillatory conditions than it was in continuous sliding. There was some support for that, because the depth affected was very much greater in oscillatory conditions than in sliding conditions. This effect of the fretting action on depth as against area seemed to him to be extremely important, because from a fatigue point of view it was the depth in particular that was of importance. A small point which arose in connection with lubricants in that connection was that if the lubricant reduced the access of moisture to the surface as well as oxygen it should, from the experiments which had been conducted at different humidities, increase the depth of the action. On the other hand, if it did, as was expected, reduce the friction force, that might wholly compensate for the other effect. It would appear from the

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results quoted that that compensation was, in fact, occurring.

Dr. W. H. J. Vernon thought it was tempting to compare the results obtained on a massive surface with the results from fretting corrosion, but probably the author would agree that it was necessary to be careful in pressing the analogy, because in a massive surface the oxide was resting on a metal substrate, and that might not always be the case in fretting corrosion, where particles were torn from the surface. Those particles, though not of the atomic or molecular scale envisaged by Tomlinson, were still quite small, and even with particles of the order of 100 Å one was dealing with particles of a similar order of magnitude to the films themselves. That was a point to be borne in mind, because there might not even be the metallic nucleus to which Dr. Clayton referred. The author referred to the oxidation of finely divided virgin material, and said : " Thus, in air at room temperatures, iron normally oxidises to the ferroso-ferric oxide Fe_3O_4, whereas the oxide formed during fretting is predominantly α–Fe_2O_3." Dr. Vernon would like to ask the author whether he was quite sure about the ferroso-ferric oxide and could differentiate sufficiently accurately to detect in the early stages of the experiment very small amounts of the ferroso-ferric oxide Fe_3O_4. How did he distinguish between γ–Fe_2O_3 and the Fe_3O_4? On the question of temperature, the author concluded that because of the absence of FeO the temperatures did not approach those produced in frictional work. This was quite sound reasoning, even though in America they had found FeO in thin films at 400 deg. Cent. The results did suggest, however, that some rise in temperature was involved. The results of Shotter, quoted in the paper, were consistent with some unpublished work of Preston and Worthington at Teddington at 100 deg. Cent., in which they showed that water reacted with a steel surface in the absence of oxygen to give a dark oxide, presumably Fe_3O_4, and that as the temperature was lowered a mixture of the yellow and red oxides was obtained, showing an increasing proportion of Fe_2O_3. They found varying proportions of oxide when the specimen was exposed in a closed system in which the partial pressures of oxygen and water vapour were varied. In systems carrying oxygen and water vapour, increase of pressure locally would increase the relative humidity, and the pressure would be increased if the relative humidity was high. Did that play some part in the mechanism ?

The author showed in Fig. 8 of the paper some interesting results upon the variation of fretting corrosion with humidity. It would be of value to have more information between 0 and 50 per cent relative humidity.

The author referred to the effects of lubricants and pointed out that lubricants which carried a greater amount of dissolved oxygen increased the fretting, which was, of course, consistent with the whole argument. Dr. Vernon would, however, welcome experiments in the converse direction, using substances which would decrease the concentration of oxygen available under those conditions, and he wondered whether that had been tried. For example, a lubricant such as oleic acid, which itself absorbed oxygen, might screen the metal from this oxidation, or, alternatively, a lubricant might be used containing a substance which would absorb oxygen or take up oxygen in a catalytic way, and so again prevent oxygen from reaching the metal.

Mr. H. N. G. Allen said that the paper was an interesting and valuable contribution to the literature on what was an important subject, particularly because it attempted to assess the extent of the damage on a quantitative basis and to correlate this with such variables as number of oscillations, load and atmospheric humidity. Fretting corrosion of closely fitting surfaces had been a great nuisance to engineers for a very long time. The speaker's firm had been troubled by it for many years, and during the last year or two had done a good deal of work in an effort to combat it. The results of its investigations had been published in the *Allen Engineering Review*, based on the work carried out in its own laboratories. As a result of this ventilation of the matter the firm had received many letters from engineering friends, often giving details of their own unfortunate experiences and clearly showing how great and widespread this trouble could be and, in fact, was, in the engineering world. The author had referred to the need to arrive at a quantitative basis and to the fact that for the time being engineers worked in particular circumstances on *ad hoc* corrective measures. That was perfectly true and, until further results were available, the practical engineer must continue to work from that angle. Although at Bedford they had later constructed a fretting corrosion machine, their earlier experiments consisted in the application on a service scale of *ad hoc* corrective measures based on existing knowledge of this effect, and he thought that one or two examples might be of interest.

An obvious method of prevention, where applicable, was that of so increasing the load between the two contact faces as to prevent the small relative movement which was apparently responsible for this damage. Examples seemed to afford conclusive proof that when this method of sufficiently increasing the load could be applied in service it was completely successful in preventing this attack.

Although fretting corrosion usually occurred in conditions where viscous lubrication could not be set up, the extent of the attack could often be much diminished by increasing the oil supply. That had been found in the case of a flexible coupling of claw type used between a turbine rotor shaft and gear shaft. The coupling claws were mounted on the end of both shafts. All the parts were of mild steel. With these couplings the two components were originally quite free to move relatively to each other, but they might become rigidly fixed together when running. The set in question, after being in service for four separate periods of about five months each, showed severe fretting corrosion in the form of irregular brown heavily pitted areas on the driving faces of the pinion claw and sleeve. Some of the corrosion debris had been carried round the edges of the prongs on to the adjacent portions of the circumferential faces. The coupling sleeve in engagement with the claw showed fretting areas of the same configuration and extent outside the oil groove and never extending inside it. At the other end, the turbine claw and coupling sleeve showed similar effects, but to a lesser degree. The load was 350 lb per square inch, and there was no real movement between the surfaces. It was impossible for an effective oil film to be set up, though boundary lubrication might occur. It was thought, however, that it might be worth while to cut additional V grooves on the prongs and note the effect. That was done and on examination after a further period of five months' service the effect was found to be represented only by a small brown discoloration at the extreme edges of the prongs, with very much less deposition on the adjacent portions of the circumferential faces. Thus, where fluid film lubrication in the true sense was impossible it would appear, in default of any other explanation, that if sufficient lubricant was available and there were relative normal movements which would attract and distribute the lubricant, the two surfaces could still be separated to an extent sufficient to prevent any serious attack. This method thus deserved consideration in those cases where it was apparently possible to apply it. On the construction of a fretting corrosion machine the efficacy of other methods of prevention could be verified, the obvious remedy of keeping the two surfaces out of metallic contact being successfully endorsed by the use of phosphate coating, the application of white lead, or a mixture of this and molybdenum disulphide.

Mr. L. Grunberg observed that one factor in particular which had to be considered when fretting corrosion experiments were carried out was the nature of the displacement which was obtained in the experiment. In practice there was a normal component of displacement as well as plane parallel movement of surfaces, but in research work most of the experiments had been done using a simple plane parallel motion. Even that simplification, however, did not tell the whole story. Various time displacement curves could be obtained according to the metal conditions which were used. In order to understand that, it must be borne in mind that the displacement was only of the order of 0·001in, and might be very much less than that, and unless the displacement was closely followed by instruments capable of doing so one might get a wrong picture of what was actually happening. At Thorntonhall they had another fretting corrosion machine which used linear oscillations as opposed to the circumferential oscillations described in the paper. They attached a proximity meter probe to the specimen and were able by an oscillograph to follow the time displacement curve under various conditions. There were two extreme cases which might occur in such an instrumental set-up. If the friction between the surfaces was very high the surfaces could become locked, and the mechanism transmitting the motion might be able to yield elastically to such an extent that in the first instant of application of a force no relative motion of the two surfaces occurred, or alternatively the friction between the surfaces was low or the rigidity of the system was high, and then the relative motion of the two surfaces would be that intended by the experimenter. In their experiment they had two types of curve. With a very rigid system and with very low friction, plotting distance (vertically) against time (horizontally) they obtained a sine wave of time and displacement ; but if, intentionally or unintentionally, the rigidity of the system was low, they obtained a square wave. In other words, while the relative movement of the two surfaces was very smooth in the one case, in the other the two surfaces went from one position into the other almost simultaneously. The importance of that was that the thermal conditions in one class of experiment might be different from those in the other. There was almost infinite velocity in such a movement in the second case, and the thermal effects might be much more severe than if the sliding was smooth.

With regard to the nature of the corrosion debris obtained, unfortunately one got corrosion debris which one would not expect. Knowledge derived from ordinary corrosion studies was not directly applicable to fretting corrosion. The author emphasised that instead of the γ modification of Fe_2O_3 one obtained the α modification of that oxide,

something which very seldom happened in other types of corrosion at the same temperature as and under similar conditions to those of the fretting corrosion experiments. They had been puzzled considerably by the corrosion debris obtained from the fretting of steel against cadmium plating. They obtained two types of oxide, one yellow and the other black, and they obtained definite diffraction pictures which suggested a very regular structure, but on searching the literature for indications of what kind of oxide would give such a structure they could find none. The oxide formed by fretting corrosion was completely different from any other cadmium oxide which chemists had studied in the past. It was obvious that those oxides or the conditions under which they were formed were rather peculiar.

Mr. O. Wright said that the author's finding that increased load increased the damage was supported by observations during actual running. The possibility of mechanical distortion being assessed in the damage must not, of course, be overlooked. The progressive nature of the damage was also confirmed in practice. It was a little disappoining that the tests were not more prolonged. With the modern power unit it was possible to have over a million oscillations in an hour. The comparatively few oscillations required to produce measurable damage emphasised the short time required to start the damage. In a laboratory experiment between a bearing ball and a glass plate, " cocoa " was evident under a lens in twenty seconds and was visible to the naked eye in forty-eight seconds. Although Dr. Almen had stated that increased susceptibility to fatigue failure was one of the main dangers of fretting corrosion, there still existed doubt whether this was so. As Dr. Hankins had stated in the discussion on the paper by Tomlinson, Thorpe and Gough presented to the Institution in 1939, it was possible during fatigue testing to get failures at the shoulder of the test piece after a fairly low number of reversals. The speaker had experienced this with a faulty chuck, failure being at less than 1 per cent of normal reversals. In all cases the fracture was initiated in the centre of a small " cocoa " area. Research had shown that micro faults in a surface could reduce fatigue endurance. The present author had carried out his tests on a high-quality surface, which presumably had been prepared in the laboratory. Had he carried out any tests on specimens prepared in the workshop ? It appeared from work done in other fields of investigation that the criterion of a metal surface was not the degree of final finish, but how that finish was achieved.

The paper presented to the Institution by Tomlinson, Thorpe and Gough suggested that there was no apparent effect from higher frequencies. Had the present author confirmed this ? Observations on high-speed rigs suggested that the increased damage was more than would be expected from the increased number of oscillations.

It would be interesting to know why the thickness of 0·010in had been chosen for the tests on the chromium and nickel-plated specimens. The chromium thickness was understandable, but 0·010in of nickel was much thicker than was normally used. When dealing with plated surfaces, had the author experimented with any other metals or plated surfaces ? Their own experience with chromium and nickel, which included thick deposits of nickel after salvage, confirmed the author's finding that chromium plate increased the damage to the mating surface on steels and nickel aggravated the damage, both surfaces suffering. They had experienced great benefit from tin and silver-plating. They used chromium plate to prevent cold welding or pick-up when steel and aluminium surfaces met under conditions which experience had taught them would induce this. They also used this method to prevent welding between two aluminium surfaces. In some cases there had been slight damage to the chromium plate, but it was rarely of a material nature. Welding and fretting corrosion were closely related, and it had been stated that corrosion occurred when the temperature achieved was not high enough to cause welding. Welding could be equally vicious. They were experimenting with phosphate films, as the result of an interview with Dr. Barwell. The most promising results appeared to be achieved when the phosphate film was impregnated with molybdenum sulphide applied in an alcohol dispersal. For extremely heavy duty, their most promising results had been achieved with a tinplate of 0·0005in, coated with a dispersal of molybdenum sulphide in a silicone grease.

Mr. J. L. Heaton observed that one reason for the lack of research on this problem was the difficulty of assessing the severity of fretting. The only type of measurement so far applied to apparatus designed to study the primary phenomenon of fretting involved an assessment of damage in terms of weight, volume or area. Such measurements, however, were not always related to the seriousness of the damage which was found in practice. When he had been in the aircraft industry not many years ago he used to see almost every day some fresh example of the havoc wrought by fretting. The use of phosphate films as an anti-fret had been practised for many years in Coventry, usually in conjunction with graphite deposited from some kind of colloidal suspension. That was regarded as quite a successful treatment, but inferior to the protection conferred by metallic plate, and especially silver plate, and only to be used when silver-plating was not convenient. He had been extremely interested in Mr. Grunberg's description of the square wave-form obtained from the oscilloscope. They themselves obtained a similar wave-form in working with a prototype apparatus which was subsequently abandoned, and the conditions of formation were precisely those described by Mr. Grunberg.

Mr. A. C. Hutchinson said that the paper was entitled " Fretting Corrosion," but, to adapt a quotation, " 'Tis wise, 'tis eloquent, but is it fretting ? " The reason for that query was that the amplitude of the movements of the author's apparatus was so enormously larger than that of previous investigators, and notably Tomlinson, Thorpe and Gough. Tomlinson obtained his characteristic fretting results with movements of the order of a millionth of an inch, while the present author obtained his with movements of the order of a thousandth of an inch, and his results in many cases were in such flat contradiction to those obtained by Tomlinson and his fellow-workers that one could not help feeling that there was some other factor operating in addition to fretting. To give one example, the present author found the amount of corrosion to be substantially proportional to the load, whereas Tomlinson found nothing of the sort. If it were assumed that, because of the large amplitude of the movements with which Dr. Wright was concerned, ordinary wear was taking place in addition to fretting, that would perhaps explain this contradiction. Mr. Hutchinson would suggest that some part of what Dr. Wright had investigated was not fretting but wear. To amplify that, a key deduction of Tomlinson and his collaborators was that reciprocation was of the essence of the phenomenon, whereas Dr. Wright made no distinction between reciprocating movement and continuous rotation. Two records that he showed on a slide were totally different. In the case of continuous rotation the debris was large and unoxidised, but in the case of reciprocating movement, under exactly the same loading and velocity conditions, the debris was microscopic and heavily oxidised. Both the work of Dr. Tomlinson and experiences of that kind could only lead to the conclusion that there was something essential in the reciprocating factor.

The author replied shortly and the meeting ended.

A Training Syllabus Guide for Tool Maker Apprentices

FOLLOWING a detailed study of training courses operated by member firms and other companies, the education and apprenticeship committee of the Gauge and Tool Makers' Association has prepared an interesting brochure entitled " A General Guide in Compiling a Syllabus of Training for Apprentice Toolmakers." The syllabus given for guidance in this publication is such that it can be adopted in part or in whole, according to the facilities available when considering the introduction of a suitable course of training for apprentice toolmakers. In the brochure, the suggested practical and technical training courses are first summarised side by side and then details of the curriculum of the practical training course are given.

At the commencement of practical training it is recommended that the apprentice should first work in the stores or on servicing in order to obtain an introduction to workshop life whilst at the same time learning the names of tools and materials. Then, entering the machine shop, experience should be given in succession on lathes, shaping or planing or slotting machines, drilling and tapping machines, millers and grinders. The syllabus is designed to give experience in each of the main classes of work carried out on these machines, as well as preliminary instruction in their care and lubrication. An appendix gives examples of the standard of job of which an apprentice should be capable of performing at the end of his period of training on the individual machines.

After this initial machine shop work, the guide suggests that the apprentice should work in succession on the bench, on jig boring, studies heat treatment and laboratory practice ; serve in the inspection department, drawing office and progress department, and conclude with a period with the millwright and machine maintenance sections of the works.

The technical course proposes part-time study at a technical institute or a works school at first, followed by the City and Guilds course for turners, fitters and machinists, or the approved Ordinary National Certificate Course in Mechanical Engineering.

Although the sequence of training laid down in various sections of the guide is recommended, it can, of course, be varied according to conditions and the aptitude displayed by an apprentice and the same applies to the time an apprentice spends in any section of the works. The brochure gives notes on the Certificate of Craftsmanship introduced by the Association and draws attention to the model Apprenticeship Indenture, which is available to both member and non-member firms. Copies of the guide can be obtained from the Association offices at Standbrook House, Old Bond Street, London, W.1, at 5s.

FIAT CRAWLER TRACTOR.—It is announced by Mackay Industrial Equipment, Ltd., that the Fiat crawler tractor, model 55L, can now be supplied with steering lever control as an alternative to wheeled steering. The 55L, like all Fiat machines, is steered by the orthodox method, incorporating multi-plate clutches and brakes, and the availability of either levers or wheel gives the contractor the choice of which ever method of control he prefers.

British Locomotives Fitted with Cam Poppet Valve Gear

Following tests made with a locomotive fitted with cam poppet valve gear in 1949, five locomotives for the London Midland Region of British Railways are being fitted with this gear, which was evolved and designed by Mr. A. Reidinger. The first of these locomotives is now in main line service.

FIVE two-cylinder class "5 MT" locomotives of the London Midland Region of British Railways are, we learn, being fitted with the "R.R." cam poppet valve gear, constructed to the designs of Mr. A. Reidinger. This kind of valve gear was first fitted on a North Eastern Region three-cylinder class "D 49" locomotive in 1949 and it was described in our issue of September 9, 1949. As a result of tests carried out at the Rugby locomotive testing station and the three years of reliable service which the locomotive completed in passenger traffic, Mr. R. A. Riddles, of the Railway Executive, decided to fit five further engines with the gear. The first of these locomotives is now in main line service.

Four of the locomotives being fitted with the gear will have camshafts fitted with cams which provide a predetermined steam distribution as ascertained by trials on the original locomotive of 1949. The fifth locomotive will be equipped with vernier adjustable cams, through which alternative independent valve settings can be made so that their effects can be investigated in a two-cylinder locomotive. The general arrangement of the new valve gear on a locomotive can be seen in one of the drawings on this page.

It will be seen from the accompanying drawing of the valve arrangement that the locomotive cylinders have valve chambers at each end, and housed in each chamber is one inlet and one exhaust valve. Because of the arrangement of the units in a horizontal position, the valves can be withdrawn when necessary without need for disturbing the cam-boxes, the main drive or the reversing connections. By using double-beat valves a relatively small lift gives large openings and enables moderate roller and cam contact pressures to be maintained. The usual spring control has been dispensed with on the inlet valves in favour of steam pressure operation. The exhaust valves are spring loaded and are continuously actuated by their cams. It is explained that this arrangement provides an effective automatic by-pass when coasting and renders unnecessary the fitting of special drifting or by-pass devices.

The cam-boxes are placed between the valve housings and bolted to footings at the top of the cylinder barrels, with the axis of the camshafts at right angles to the longitudinal centre line of the cylinders. Each cam-box is a complete self-contained unit incorporating a camshaft, intermediate lever assemblies and reversing gear. The camshaft carries two cams for each of the inlet and exhaust valves and is driven through a wormwheel at the outer end. The drive for the valve gear is taken from a wormwheel gearbox, which is mounted on a return crank on each side of the locomotive. Floating rods are used to counteract torque in this unit and it is coupled to the cam-box wormshafts by universal shafting fitted with flange connections. The reversing and notching-up gear is operated through a universal shaft connecting the driver's control in the cab with a self-locking reduction gearbox, which securely holds the gear in its set position. From this gearbox motion is transmitted through bevel gearboxes and intermediate shafting to the cam-boxes on each side of the engine.

When the locomotive is stationary, the steam inlet valves are in the open position. On opening the regulator, steam passes through piping from the regulator valve to the valve closing pistons in the valve covers. This steam pressure in closing the valves brings their spindles into positive contact with their cams through the tappets in the sides of the cam-boxes.

The exhaust valves, as already mentioned, are spring-controlled and are, therefore, at all times actuated and positioned by the exhaust cams. Pressure is not used to control the exhaust valves because of the difficulty which would be experienced in maintaining a steam-tight packing for actuating pistons which, unlike the case of the pistons controlling the steam inlet valves, is clearly essential in the case of exhaust valves. This arrangement also makes the engine more responsive to the regulator, because the exhaust valves are at all times correctly positioned in relation to the cams.

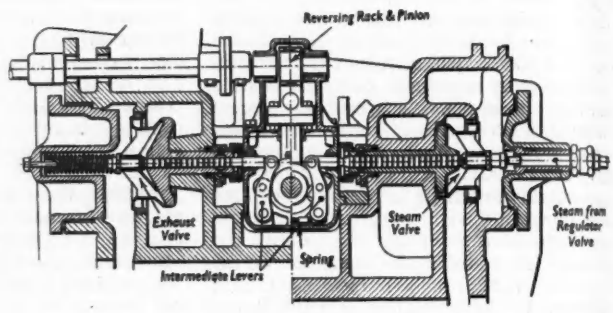
The camshafts rotate at the same speed as the locomotive driving wheels and are driven by a dog having helical keys engaging with helical spline ways in an inner driving sleeve. The main drive wormwheel is mounted on and bolted to the driving shank, in the bore of which is fitted the inner splined sleeve. Each inlet valve has a cut-off cam and a pre-admission cam and each exhaust valve a compression cam and a release cam, and the camshaft is splined in such a way that, when slid along, it can impart an angular movement to the cams through the helical spline in the inner driving sleeve.

Reversal or adjustment of cut-off is obtained by moving the camshafts in an axial direction through a rack and pinion. This movement draws the camshaft through the cams and, by means of the helical splines which engage keys in the bores of the cams, causes the cams to be turned relative to each other.

All valve events are based on the cut-off cam and for any cut-off the pre-admission cam opens the inlet valves for admission and, as the cut-off is shortened, pre-admission becomes earlier and "lead" is increased. For all running cut-offs a full valve lift and hence a full port opening for steam inlet is obtained. For any cut-off the "release" cam opens the exhaust valves fully and, as the cut-off is shortened, release gradually becomes earlier, but it is always later relatively to that obtained with link motion gears. Shortening the rate of cut-off causes the exhaust valves to close earlier, thus positively controlling the point of compression relative to the cut-off.

There are four intermediate lever assemblies in each cam-box, one for each of the valve spindle tappets working in guide bushes fitted in the sides of the cam-box. The intermediate levers are fulcrumed at their lower ends on rods fitted on each side in the bottom of the cam-box. At their upper ends the levers contact the cam-box tappets and their purpose is to increase the lift of the valves over that given by the form of the cams. They give a direct thrust on the tappets and carry follower rollers, which run on the cam profiles.

Each steam inlet lever is fitted with a rocking beam having two rollers, one at each end of the beam. One of these rollers runs on the cut-off cam and the other on the preadmission cam. This arrangement is necessary on account of the differential cam action and the relatively large angular displacement given to these cams when the gear is reversed or when altering the rate of cut-off. Coil compression springs acting between the lower ends of the steam inlet levers serve to keep the follower rollers in constant contact with the cams. This arrangement has been adopted on the steam inlet side because valve control springs are not used, owing to the valves being steam-controlled.

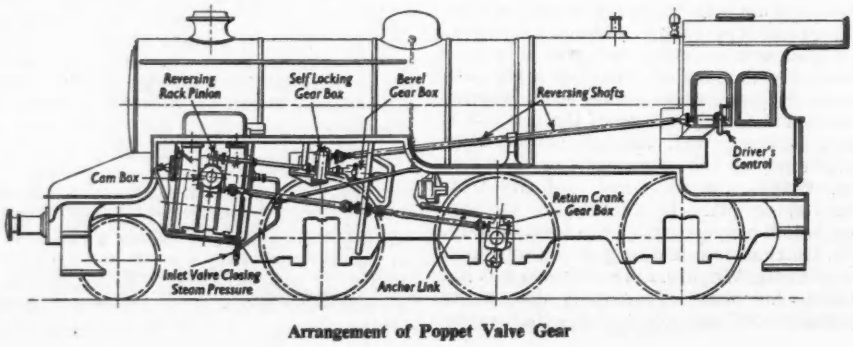


Steam and Exhaust Poppet Valves

The intermediate levers fitted on the exhaust side also have two rollers, one for each of the exhaust cams. These rollers are not fitted on a rocking beam because the cams have only a small angular displacement relative to each other.

The valve spindles are mechanically lubricated and the cam-boxes, return crank gears and the reversing cam-boxes are arranged for oil-bath lubrication.

The valve gears, which were supplied by Locomotive Valve Gear, Ltd., of 47, Victoria Street, London, were made by J. L. Jameson, Ltd., West Street Works, Ewell, Surrey.



Arrangement of Poppet Valve Gear

GAS SCRUBBERS.—The Power-Gas Corporation, Ltd., of Stockton-on-Tees, the licensees for Pease Anthony scrubbers, informs us that it now has pilot plant unit available for experimental purposes on a variety of applications. The unit, which is mobile, can handle 500 cubic feet of gas per minute and is capable of dealing with micron and sub-micron dusts and fumes.

TOOL-STEEL DIE BLANKS.—We are informed by Bowser, Monks and Whitehouse, Ltd., 45A, Market Place, Doncaster, that it is now distributing in this country a range of standardised tool-steel die blanks. These blanks are cut to size and precision ground all over ready for layout, and their use reduces necessity for tool-making firms to maintain large stocks of tool steel and saves the time required to cut down large pieces or bars before actual tool making can start. These "U-blanks," as they are known, are in "Arne" Swedish oil-hardening chrome-tungsten-vanadium steel and are supplied in a very large number of standard sizes with surface dimensions from 2¼in square to 8in by 16in, in thicknesses from ⅛in to 2in. The makers say that users can be supplied with blanks from stock by return of post.

Operating Experiences with Two Gas Turbine Locomotives*

By A. W. J. DYMOND, B.Sc., M.I.C.E., M.I.Mech.E.

No. II—(*Concluded from page 280, February 20th*)

The Metropolitan-Vickers Locomotive No. 18100

This locomotive, after having made only one or two short movements under its own power in the works yard at Trafford Park, was towed to Swindon, where it arrived on December 17, 1951. As practically no facilities were available for any serious running tests and adjustments before delivery, some weeks elapsed after its arrival in Swindon before it was deemed ready for operational service. The first period, therefore, was occupied on a number of what might be termed "works trials," both light engine, and with empty stock, the first of these (a light engine trip) taking place on January 3, 1952, between Swindon and Stoke Gifford (Bristol). The locomotive also ran a series of empty stock trips between Swindon and Plymouth and between Paddington and Plymouth, Wolverhampton and Bristol. The outstanding features of these trials were the taking of a train of seventeen empty stock (532 tons) to Plymouth from Swindon, via Reading, on March 6th and the restarting trials on the 1 in 42 gradient at Hemerdon on March 9, when 609 tons tare weight (eighteen coaches) were successfully restarted. At this date some 3200 miles had been achieved.

The general behaviour of the locomotive throughout all this preliminary running gave no cause for anxiety. Such adjustments and modifications as were made were solely those likely to arise with a new design being first put into operation. There was some difficulty with hunting in the main control gear, and some time was spent in suppressing this. No major incident intervened, however, before the first passenger train trip on April 4th, when a nine-coach train was taken from Paddington to Bristol and back (depart Paddington 11.15 a.m., depart Bristol 4.15 p.m.), mileage at this date 4500 miles. The engine then settled down for staff training purposes to run a trip to Bristol and back each day over a period of about one month. One day was lost during this period owing to inability to restart the turbine while on the way to take up the day's work. This was due to an electrical fault on the battery starting system. The engine took up its duty the following day without further difficulty. By the end of May 15,500 miles had been run with no serious incident. At the end of the first week in June an oil pipe feeding one of the main bearings of the turbine fractured, and as the amount of dismantling to correct this was considerable it was decided to anticipate a projected week's stoppage in shops by a few days and the engine accordingly was withdrawn from service. The intention to withdraw the engine for a week arose from the desire to carry out simultaneously some modifications to the exhaust trunking, the motor traction gearcases, and the main side frames of the bogies. None of these modifications was the result of any serious defect becoming apparent, but each was deemed necessary in the endeavour to secure the maximum degree of reliability in the locomotive when finally passed to the railway for independent operation. It is to be borne in mind that the joint responsibility for the locomotive, which was shared from the outset equally by the railway and the firm of Metropolitan-Vickers, persisted right through all the preliminary trials and during the actual service runs, and indeed remains up to the present. In the middle of July the engine was put to work two trips a day to Bristol and back (some 2900 miles per week) and by the beginning of August nearly 30,000 miles had been logged. Early in August the engine was put on to the Plymouth run, making the round trip from London to Plymouth and back in one day. It remained on that service up to mid-September, when it was stopped owing to a serious defect in the control circuits, causing a small fire which entailed considerable renewal of the wiring and components of the control gear. During the ensuing stoppage the bearings at the pinion ends of the traction motors were changed from oil to grease lubrication. This was deemed desirable owing to the oiling system having required fairly considerable replenishment due to persistent loss of lubricant. At the date when the stoppage occurred the engine had achieved 42,021 miles and completed 1237 turbine hours.

As in the case of the Brown-Boveri history the chronological narrative terminates at this point, both locomotives being then simultaneously in the shops for attention. Neither, however, was then receiving anything in the nature of a general overhaul.

General Comments on the Behaviour of the Metropolitan-Vickers Locomotive

In the case of the Brown-Boveri machine it was possible to give some comprehensive comments on maintenance, operation, fuelling, &c. Owing to the much shorter mileage achieved in considerably less time by the Metropolitan-Vickers, together with the fact that it has been in the hands of the maker's staff (except for driving duties) throughout the whole period since its delivery, similar detailed comment on this locomotive is not yet possible. Such maintenance work as has been periodically necessary has been carried out by the firm's staff, often in conjunction with some slight modifications revealed to be necessary by the current running experience. The picture is thus confused in some degree and no useful purpose is served in endeavouring to generalise. On the question of fuel, no very elaborate storage facilities for refuelling the locomotive are necessary, since the gas oil used is the same as that already available for the diesel railcars and diesel-electric shunters. The consumption rate, initially rather high at 3·77 gallons per mile, settled down to 2·97 gallons per mile after adjustment to the idling control consumption. Comparing this consumption of gas oil with a gross calorific value of 19,500 B.Th.U. per pound, with the equivalent coal at 14,000 B.Th.U. per pound, gives an equivalent coal consumption of 34·6 lb per mile. This figure, subject to the same reservations as that quoted for the Brown-Boveri, is nevertheless very near to that figure and suggests, in the absence of precise figures from dynamometer tests, that the thermal characteristics of both locomotives are very closely allied. The consumption of lubricants has been quite modest, except in regard to that for the traction motor gearcases, which were modified after months of running to improve the oil seals. The make-up of main turbine lubricant has been at the rate of 13–14 gallons per month. The utilisation of the locomotive has been in some measure restricted by most of the factors referred to in the case of the Brown-Boveri machine, with one important exception. The excellent tractive performance with heavy trains on the South Devon banks has made possible the employment of the engine on services to this area without the reservations applicable to the Swiss engine. Up to the time of writing no considerable experience had been obtained with the train heating boiler; consequently the restriction on the use of the engine imposed on the Brown-Boveri engine did not apply. The engine has been stabled at Old Oak Common throughout.

Some Generalisations

At this point the narrative breaks off, but the two locomotives will have been restored to service subsequent to the time of sending this paper to the press, further experience will have been acquired, and further development work undertaken. It will be appropriate here, however, to attempt to summarise some opinions formed thus far.

In the first place it should be stated quite simply that for locomotives of such a novel type, handled, with assistance, in part from the builders' staffs, by the normal railway personnel, the general experience has been distinctly encouraging. As the narrative has revealed, there have, of course, been incidents involving withdrawal from service. In addition, there have been many hours, at night and at week-ends, of arduous work, particularly in the initial stages, correcting trivial defects or maladjustments. Such is to be expected of a new design of any accepted principle. No more than this has been necessary with either of these gas turbine locomotives, with the exception, of course, of the major incidents which have been recorded. On the road the engines have put up some very impressive performances, which may be exemplified by the comparison of the Brown-Boveri dynamometer car record with that of a "King" class engine on the West of England route. The climb from Cowley Bridge (Exeter), at which a permanent speed restriction of 50 m.p.h. must be observed, to the summit of Whiteball is about 18½ miles. The Brown-Boveri, working for the most part of the time below maximum power, was nevertheless able to breast the summit at 18–20 m.p.h. faster than the "King." Similarly, the climb up from Athelney to Somerton of about 8 miles of 1 in 264 reduced the "King" speed from 70 to 52 m.p.h., while the Brown-Boveri, although again not working at maximum power, did not drop its speed below 66 m.p.h., and could have maintained the 70 m.p.h. which was the speed past Athelney, were it not for the necessity to avoid running too far ahead of booked time. It may be safely stated that the sustained high rate of drawbar horsepower here shown is beyond that normally possible even with the maximum continuous steaming capacity of any steam locomotive in the country. Although no dynamometer car tests have yet been made with the Metropolitan-Vickers engine, some very fine runs have been recorded on normal or special services. For example, on a special run with a train of 498 tons passing Taunton at 60 m.p.h. the 107 miles to Reading (passing at about 45 m.p.h.) was covered in 90 minutes including the climbs to Witham and Savernake summits. Both locomotives on regular service have consistently and frequently made up substantial margins caused by late departures, mostly not of their causing. From the point of view of the driving staff this makes the locomotives very popular, their complete mastery of the trains being fully appreciated and made use of by the drivers. After the initial period of training, during which the novelty of the engines has perhaps caused the trainee drivers some misgivings, most of those passed to take charge have shown considerable confidence and competency in dealing with the engines. This is most marked, of course, with the Brown-Boveri, which has been running many months in sole charge of driver and assistant, with only occasional visits from headquarters inspectors, and practically none from representatives of the builders. No doubt the same will prove to be true of the Metropolitan-Vickers when the firm's staff, who up to now have always ridden with the engine, are finally withdrawn. Given the fact that driving technique for these machines is not a major difficulty, there would be good grounds for assuming that the utmost could be made of the high user potential of each locomotive if a number were in use simultaneously, and the American project for ten such engines, when fully implemented, may be confidently expected to confirm this.

The operating cost, on the usual "per mile" basis for fuel alone does strike a somewhat disheartening note compared with diesel and steam locomotives. If the day-to-day maintenance and servicing of a fleet of such locomotives is very slight (as would appear from experience to be extremely likely) and a high utilisation factor is achieved, however, the advantages of being able to provide units of such power within normal space and weight limitations make the overall economic consideration much more favourable. The difficulty with only one or two locomotives is to achieve a high utilisation factor; consequently the actual operating cost affords only a slight criterion on which to base an opinion.

So far as the physical phenomena associated with these engines are concerned, relatively little difficulty has been experienced. The noise, although noticeable enough, is only of inconvenience when stationary, and is practically inaudible in the train either stationary or running. Smell has been found to vary with the rate of working, being worse when idling or running light and practically absent when on medium load or more. The use of the residual fuel on the Brown-Boveri, with the attendant combustion difficulties, has aggravated the smell problem, but it is hoped that the work at present proceeding on the combustion will eliminate or at least mitigate this. Practically no complaint has arisen on account of smell concerning the Metropolitan-Vickers engine.

The unusual quantity of air being inhaled and

* Paper, Institution of Locomotive Engineers, February 18, 1953. Abstracts.

exhaled has given rise to doubt as to the effects of this on bridges and other structures. The only indication of anything unusual has been the fairly heavy falling of soot and dirt from tunnel roofs, station verandahs, &c., at the initial passage of the engine. After repeated journeys the falls have been very much reduced, or cease altogether, and an item could almost be claimed on the credit side for cleaning structures for the civil engineer. No trouble has been experienced due to the large intake of air. Experience to date has been, therefore, that no insurmountable disadvantages arise due to noise, smell, nor air displacement. In this connection it would be appropriate to record that, although great care has been taken on the Metropolitan-Vickers engine to filter all air entering the compressor, while no filters at all are provided on the Brown-Boveri engine, little difference in the performance of the machines due to this variation between them has been noticed. Both engines inhale air from dust or smoke-laden surroundings—notably in tunnels. In the case of the Brown-Boveri the compressor is periodically washed out. In the case of the Metropolitan-Vickers the filters are periodically cleaned. But no significant falling off of performance has been noticed in either case.

The radius of action of both locomotives has been in some measure restricted by the fuel tank capacity provided. This has proved ample for the 225 miles' run from Paddington to Plymouth specified when the projects were first examined. But experience has shown that advantage could have been taken of further short trips at the ends of long runs of up to 250 miles, were it not for the necessity to refuel. So far as the Brown-Boveri is concerned, this is of some importance, as the necessity for special heating facilities for the residual oil at motive power depots makes multiplication of these expensive facilities (for one locomotive only, as in the present case) a very costly provision. In the case of the Metropolitan-Vickers arrangements are in hand to increase the tankage on the locomotive and provide in addition a fuelling pump on the locomotive so that gas oil can be taken direct from a tank car. In either case it would seem that the omission of the double-ended driving facilities and the rearrangement of gear on the frame could have made possible substantial increased fuel capacity, with great advantage for these experimental machines. An additional virtue arising therefrom would have been greater facility for the provision of gangway connections to the main train, which would be of great advantage in dealing with many features which arise with a novel machine.

On the question of the train heating boilers much could be said, which has been thought better to leave out of this paper. Suffice it to remark that the provision of a boiler-tender-cum-baggage-car, particularly if associated with the gangway connection envisaged, would have eliminated or reduced engine days lost solely due to the train heating boiler. Moreover, the space, not only for the boiler, but also for its attendant water tank, could again have provided additional fuel space. If the locomotive could be fuelled for twenty to twenty-two hours in traffic per diem, which is otherwise well within its capacity, many more revenue-earning miles could be achieved. The importance of this in relation to capital cost does not need emphasis.

On the question of capital cost the author makes no excuse for refraining from quoting figures. Both locomotives are prototypes, with all that that statement implies in relation to cost. The intention was to conduct an experiment on the principle of gas turbines for railway traction. Given that the experiment might show real promise, capital costs of further units developed from that experiment would be markedly influenced by the lessons learned from the prototypes.

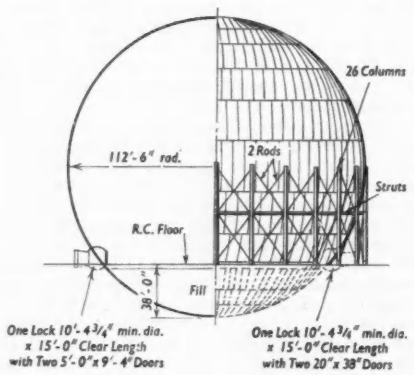
There remains the important matter of operating costs—particularly and mainly of fuel. This is ground upon which the author treads with trepidation. Certainly it can be said that the initial concepts of the designs are now six or more years old, and in the gas turbine world six years is a long time in which efficiencies of compressors and turbines have made advances. Moreover, it is for debate whether to-day a machine would incorporate the two-shaft principle or whether two complete gas turbine units, each of half the total required output, should be provided, to overcome the drooping characteristic of the efficiency load curve. These are questions best answered by those engaged on gas turbine development in general. There is also the development of gas generators working on the diesel principle to consider, bearing in mind the much reduced size of the turbine and much less onerous conditions under which it would operate when working in conjunction with such generators. The possibilities of these and, no doubt, other approaches to the problem, on the vital question, so far as this country is concerned, of coal-burning gas turbine locomotives, are of great significance. The knowledge that projects working along such lines have emerged, or are emerging, gives additional value to the experiment which is now proceeding on British Railways.

American Engineering News

(By Our American Correspondent)

The Submarine Intermediate Reactor of the U.S. Atomic Energy Commission

An unusual structure is now being erected to house the nuclear submarine power plant which is under construction by the U.S Atomic Energy Commission for the U.S. Navy. As shown in the accompanying drawing, the structure consists of a saucer-shaped concrete foundation and a 225ft diameter fabricated steel sphere. Known as the submarine intermediate reactor (SIR), the project is under the direction of the Knolls Atomic Power Laboratory, which is operated at Schenectady for the A.E.C. by the General Electric Company. The reactor, and the sphere enclosing it, are being built on a site at West Milton, New York, about 18 miles north of Schenectady. The spherical design


26 Columns
112'-6" rad.
2 Rods
Struts
R.C. Floor
Fill
30'-0"
One Lock 10'-4 3/4" min. dia. x 15'-0" Clear Length with Two 5'-0" x 9'-4" Doors
One Lock 10'-4 3/4" min. dia. x 15'-0" Clear Length with Two 20" x 38" Doors

	Cubic feet.
Gross volume	5,964,000
Less fill	453,000
	5,511,000
Less cont.	200,000
Net volume...	5,311,000

Spherical Housing for Submarine Intermediate Reactor

of the reactor building was adopted to provide additional protection to operating personnel and to off-site areas during test operations, beyond the many safety controls of the reactor itself. The periphery of the building will be 706ft in extent. The sphere will rest on the concrete "saucer," which is 179ft in diameter and 42ft deep. A ring of steel columns set on concrete outside the structure and reaching to the middle of the sphere will give further support to the building. Welded steel plates will make up the skin of the ball. The plates will be hoisted into position by a derrick crane mounted on top of a temporary central steel tower. Every weld in the structure is required to be subjected to radiographic inspection. To facilitate this work at the sphere bottom a 4ft space has been provided temporarily between the base of the sphere and the concrete. After testing is completed this space will be filled with concrete and aggregate. Inside, the concrete floor on which the reactor will rest will be slightly above ground level and the well of the "saucer" beneath the floor will be filled with a compacted mixture of aggregate and earth. As soon as the columns are in place the first ring of plates will gird the sphere at its centre and assembly will proceed both upwards and downwards. Meanwhile the hull of the submarine will be assembled just outside the building and when the latter is completed and tested the hull will be skidded into the huge ball through a special wall section. The reactor designed for the project will use liquid sodium metal to remove the heat from the reactor core and transfer it to a "boiler" where water will be converted to steam. The steam will then drive turbines that propel the submarine. The Electric Boat Division of the General Dynamics Corporation, of Groton, Connecticut, is erecting the hull and power plant. The sphere-shaped building for the reactor is being constructed by the Chicago Bridge and Iron Company.

A Seven-Year Reclamation Programme

The Bureau of Reclamation has submitted to the new Congress of the United States a report outlining a seven-year programme for the continued development of the water resources in the western part of the country, to supply new or supplemental irrigation water to 3,111,700 acres of land and to effect the installation of 2866MW of hydro-electric generating capacity. The programme is contingent upon the future authorisation of some projects and appropriations made by the Congress. The cost of the programme has been estimated to be about 50,000,000 dollars more per year than in the past several years, when reclamation expenditures have varied between 200 million dollars and 366 million dollars annually. The peak expenditure necessary to carry on the proposed works would be 412,694,000 dollars in 1956. The total cost of the seven-year plan would be 2,110,835,000 dollars. The supplemental water supply would suffice for the establishment of 18,000 new farms and in an increase in production on 37,000 farms operating at present.

The installation of more than 2800MW additional generating capacity would bring the total capacity generated by Bureau of Reclamation multi-purpose projects to more than 7300MW. The report shows that the reclamation States have utilised only about one-fifth of the total annual stream run-off of approximately 392 million acre-feet. Under present reclamation repayment requirements and with existing technical knowledge and facilities, it is believed that about one-third of the total run-off could be utilised. Only a fraction of this would be accomplished under the present seven-year programme, although basic planning and investigations would be undertaken during this period for additional future development. A constant westward movement of population and a gradual shrinking in the margin of food supply for the growing population is noted in the report. There has been a decline from 3·8 to 2·7 acres of crop land per person during the last thirty years, but mechanisation and improved production methods have permitted the country to live better than ever before.

The report recalls that the reclamation programme, as established by the Reclamation Act of 1902, and subsequent congressional actions, aims at the full development of water and land resources in the western United States so that the west can come to its fullest economic stature and help provide for a constantly growing population; but interpretations of the practicable rate of development differ. Although reclamation pays its own way through reimbursements from water users and from power revenues and other benefits, the scope of its programme at any given time is determined by Congress. To that extent, therefore, the 1953–59 plan now presented is provisional.

A New Open Hearth Shop at the Indiana Harbour Steel Works

A new melting shop containing four 225-ton open hearth furnaces is now in full production at the Indiana Harbour Works of the Inland Steel Company, near Chicago, Illinois. These furnaces will add some 700,000 ingot tons to the works' steel-making capacity, which will then be 4,000,000 net tons per annum. The melting shop is built on newly made land extending about 2 miles out from the natural shore

line of Lake Michigan. This land is a peninsula extending north from Indiana Harbour, Indiana, which has been built up through the years by the dumping of slag from the blast-furnaces and open hearth furnaces of the works. Because of difficulties previously experienced in constructing buildings on such land, it was decided to drive some 10,000 tons of steel piling to support the foundations of the open hearth shop.

An interesting aspect of the design of the furnace shop is the use of air conditioning, which is extended to all crane cabs. The office and laboratory building, which houses the office space, chemical laboratory facilities and locker rooms for all personnel, is windowless and is fully air conditioned. The main open hearth building has side openings placed much lower than is conventional on this type of building. It is believed that this arrangement will provide a maximum updraught to carry away smoke and dirt. The building is illuminated by a combination of mercury vapour and incandescent lighting elements. Each furnace is connected with the chemical testing laboratory by both a "tele-autograph" communications system and a pneumatic tube; the tele-autograph offers an electro-mechanical means of sending written messages in either direction, while test samples from each heat of steel can be sent back and forth through the pneumatic tube.

The task of adding de-oxidising or alloying elements to the steel as it flows from the furnace into a ladle has been facilitated by several new pieces of equipment installed behind the furnaces. At one end of the pouring aisle a crusher has been situated, to prepare such materials as manganese and silicon for use as ladle additions. The materials are then stored in bins suspended from the platform behind each furnace. When needed, the materials are lifted by an electrically driven jib crane, operated by one man, which swings in the fashion of a boom fastened to the back of the furnace. This crane carries materials to individual weighing scales, and then drops them into the ladle. Most of this work had previously been done manually. Another innovation in open hearth construction is the installation of a 20,000 lb hydraulic freight lift from ground level in the open hearth building, to the charging floor, whereby large quantities of refractory brick and lump alloys can be stored on the lower level of the building and remain readily accessible to the furnaces. The entire charging floor section of the open hearth building is unusually large, and provides a spacious working area in front of the furnaces to facilitate orderly operation with an additional margin of safety.

High-Frequency Calibration of Magnetic Materials

The National Bureau of Standards, Washington, recently established a calibration service for determining the radio-frequency permeability and loss factor of magnetic materials in the frequency range between 50 kc/s and 30 Mc/s. The primary calibrating standard employed is a coaxial line of variable length constructed to high dimensional accuracy. The characteristics of magnetic materials, such as ferrites and powdered irons, are determined in terms of the variation in the length of the line. The Bureau has also developed a secondary standard of calibration which may be simply reproduced and utilised in the manufacture of magnetic materials.

To determine the characteristics of magnetic materials, experiments have been conducted on thousands of compositions at the N.B.S. Little difficulty was encountered in determining the d.c. characteristics of the materials; these experiments are now being performed with comparative ease and accuracy. However, the procedures were not suitable for determining the behaviour of ferrites and powdered irons at high frequencies. Such high-frequency characteristics are commonly expressed by the r.f. permeability and the loss factor of the magnetic materials. The determination of these factors, besides being of interest to the designer of electronic equipment, is important to the manufacturer of magnetic materials, to be used as a basis for quality control of the manufacturing process.

The method of measurement depends on the change in inductance of an accurately machined coaxial line when a sample of magnetic material is inserted. The variable length coaxial line, which is illustrated in Fig. 1, is accurately calibrated in nineteen 1in steps and includes a micrometer system permitting the measurement of variations to within 0·0005in along the 20in range. In machining the components of the apparatus, all tolerances were held to ±0·0002in. The line is made from non-magnetic materials to reduce the possibility of extraneous magnetic fields affecting the measurement. In a representative investigation, a sample of magnetic material is ground into the shape of a coaxial disc large enough to fill a section of the space between the conductors of the coaxial line, grinding tolerances being maintained within ±0·0002in. The output terminal of the coaxial line is connected to the "unknown" terminal of an r.f. bridge suitable for measuring inductance in the frequency range at which the material will be used. In the first instance, the bridge circuit is balanced without a sample in the line and the coaxial segment extended to almost its fullest length. The disc of magnetic material is then placed on the central conductor of the line. A metal cap holding the disc in place short circuits the end of the coaxial line. The resulting bridge unbalance is corrected, balance being restored by a combined manipulation of the resistance reading arm on the bridge and a reduction in the length of the line. The variation in length is directly proportional to the permeability of the magnetic material relative to air and thus constitutes a primary method of measurement. The difference in resistance readings is a measure of the loss factor of the material and is limited only by the inherent accuracy of the bridge instrument.

It is evident that such precise and delicate calibration equipment cannot be used for routine inspection on a production line in a factory. The method which is now more commonly employed in routine measurements in America makes use of a toroidally shaped ring upon which a number of windings have been placed. Quality control is achieved by comparing representative products with this "standard." The major disadvantage of this method, apart from the necessity of winding a large number of turns on each toroid to be tested, is the poor accuracy resulting from shunting capacitances and displacement currents, especially in the case of materials with high dielectric constants. There was need for a device that would give reasonably accurate indication of the variation of the finished product with respect to the "standard." The secondary standard of calibration which has now been developed by the National Bureau of Standards is designed to yield the necessary information and is rugged enough to become an integral part of a works production line. Its accuracy is limited only by the precision of the bridge instrument used in the calibration. This secondary standard is a r.f. permeameter—a modification of an instrument developed for the measurement of permeability alone at low frequencies. Its operation depends on the change in input impedance reflected into the primary of a transformer by load variations in its secondary. The transformer of the r.f. permeameter is composed of a reference toroid and a length of coaxial line; changes in the secondary are produced by the insertion of a toroid of magnetic material into the coaxial line. The permeameter, which is shown in the centre of the accompanying illustration, is machined from 2in diameter brass bar into a cylinder with an inside diameter of 1½in and a length of about 1¾in. Both ends of the coaxial line are fitted with shorting covers. The top cover is readily removable to admit the sample materials. It is made of beryllium copper so that the bearing surfaces can be machined to provide a springy, yet electrically tight, fit. The bottom cover is attached to the cylinder by screws and carries the $\frac{3}{16}$in diameter central conductor of the coaxial line. A hole is tapped in the cover to receive a cable plug. A shelf made of low-loss insulating material separates the upper third of the cylinder from the lower portion. The coaxial line is designed to receive toroidal rings having a minimum inside diameter of $\frac{7}{16}$in, and a maximum outside diameter of 1½in. A wall thickness of ¼in was chosen to improve the high-frequency shielding and to give ample mechanical strength. The insulating shelf acts as a holder for the material to be tested.

For inspection purposes, a toroidal ring is slipped over the central conductor and rests on the bottom cover of the coaxial line. A number of windings, suited to the conditions of the experiment, are wound on the toroid. One end of the winding is connected to the cable

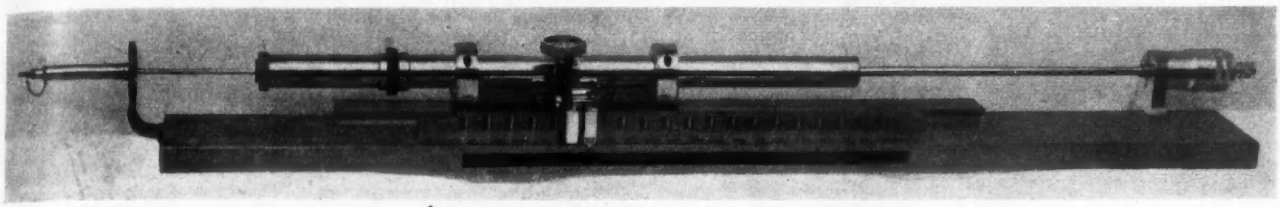


Fig. 1—Primary Calibrating Standard for Magnetic Materials

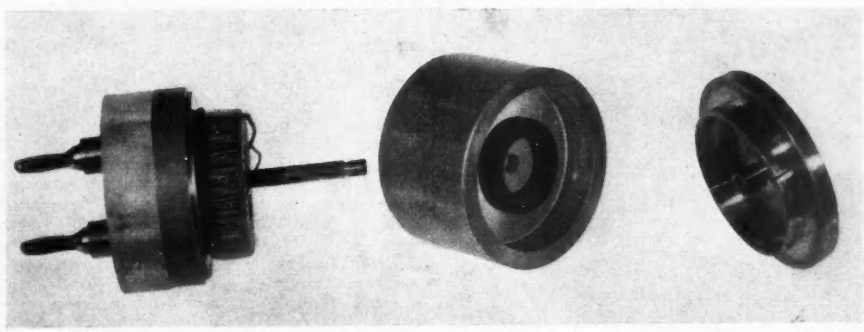


Fig. 2—Secondary Calibrating Standard for Magnetic Materials

plug and the other end to the coaxial line, thus making the system electrically unbalanced. In this position, the toroid acts as a reference for the measurement by becoming the primary of a transformer, the secondary of which is the metallic portion of the coaxial line. A connection is made between the cable plug and an r.f. bridge. The bridge is first balanced with the secondary of the "transformer" unloaded. The ring of magnetic material to be tested is then placed on the shelf in the line, and the impedance bridge is rebalanced. The variation in input impedance, as read on the bridge, is the quantity from which the permeability and loss factor of the magnetic material are computed.

An Introduction to Hydraulic Servo-Mechanism Theory*

By H. G. CONWAY, M.A., M.I.Mech.E.,† and E. G. COLLINSON, B.Sc.‡

No. II—(*Concluded from page 296, February 20th*)

Design Problems

Oil Compressibility.[4]—In some servos, particularly those on aircraft flying controls, the compressibility of the oil used is of considerable importance. The most important factor in its compressibility is due to the amount of air which may be entrapped in the oil, and special precautions may have to be taken to make sure that it is eliminated. It is quite possible for an otherwise stable servo to become unstable due to frothing of the oil. It is often difficult to prevent the oil in a system from eventually entraining air. The effect is more pronounced at low working pressures. Rendel and Allen (1951) show that the reduction in the bulk modulus of the fluid due to entrapped air is small at pressures above 1500 lb per square inch.

Pumps.—This paper is not concerned with the performance of hydraulic pumps in themselves; however, inertia effects and leakage are important when these pumps are used in hydraulic transmission servos. In some servos, accumulators are used in parallel with the pump, and the effect of variation of operating pressure, due either to the unloading system or to sudden peak demands, may be important.

Hydraulic Jacks.—The hydraulic jack has rarely much effect on the performance of the servo except in so far as backlash of the connection between the jack and the output may be important; however, the use of a differential area system, whereby the jack volumes are not the same, enables backlash to be eliminated by pre-loading the jack linkage. The use of a differential jack has a further advantage that the operating valve is of the three-way type in place of the normal four-way type. (A disadvantage is referred to under "*Valves.*")

The effects of backlash can be serious; the authors know of one aircraft control which can be completely destabilised by a clearance of 0·003in in the jack attachments. Many otherwise admirable servos are spoilt by the introduction of linkages with several pivots, each with 0·001in to 0·002in clearance.

Valves: (*a*) *Valve Geometry.*—The spool of the valve must be in static balance due to pressures at the ports. This means that there must be an annulus around each port or that the ports must be opposed. The first solution will shorten the leakage path between one port and another but will tend to balance leakage forces. When leakage occurs between the spool and the sleeve, the pressure distribution on the spool will inevitably be unsymmetrical and will tend to push the spool to one side, giving rise to "stiction" or friction forces (see below). This can be mitigated by re-balancing the pressure distribution as often as possible by means of small circular grooves in the spool or sleeve.

Obviously, the pressure in the groove must be constant all the way round and therefore there will be a series of small unbalanced areas instead of one large one.

For a particular hydraulic servo design the valve orifice area when fully open will generally be determined on theoretical grounds, although it is usual practice to allow quite a reasonable pressure-drop through the valve when dealing[5] with maximum flow rates, assuming that the maximum velocity and force demands do not occur simultaneously. Valves of small diameter with long travels are very rarely used, since it is generally desirable to keep the valve motion to a minimum, to minimise the error of the servo and often also to limit the demands on the electrical transducer which may be operating the valve. (On the other hand, long travel valves of small diameter have advantages as regards friction.) Generally, a valve diameter is chosen of two or three times the minimum theoretical diameter, enabling valve travels less than ±0·05in (often as small as ±0·005in) to be used.

The problem of valve travel can be studied further, theoretically. The servo shown in Fig. 1(*a*) illustrates this.

If θ_i is the valve displacement from neutral and θ_o the jack piston displacement, then the valve opening is proportional to $\theta_i - \theta_o$. The flow into the jack is proportional to this, that is, $q = K(\theta_i - \theta_o)$.

But the velocity of the jack is $\dot{\theta}_o = q/A$ at low frequencies and so:

$$A\dot{\theta}_o = K(\theta_i - \theta_o)$$

or

$$\theta_o = \frac{K\theta_i}{K + As} = \frac{\theta_i}{1 + \frac{As}{K}}$$

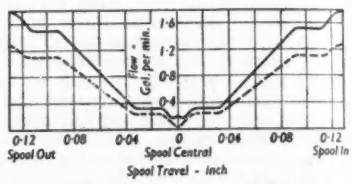
Thus at low frequencies the unit has a response equivalent to a simple time constant delay, the time constant being A/K. The parameter K is the rate of flow per unit valve opening, that is, the gain of the valve, and hence, for a fixed flow, is inversely proportional to the valve travel.

In an electro-hydraulic servo, as shown in Fig. 2(*a*), the overall gain is the product of the hydraulic and electrical gains. There are occasions when it is desirable to reduce the hydraulic gain and increase the electrical factor. This is done by reducing the size of spool and increasing the travel, and is offset by the reduction in the valve-transducer time constant.

(*b*) *Valve Ports.*—Although a wide variety of designs have been used from time to time, most designs make use of annular ports in the two valve elements, or grooves in the valve plunger or spool and drilled holes in the valve sleeve. The drilled hole construction is of particular interest when using a valve with deliberate underlap, since the underlap orifices may consist of small drilled holes which are easier than annular ports to position in manufacture. The production of quantities of valves of similar performance has presented considerable manufacturing problems in relation to the underlap and overlap dimensions of the valve lands. It is not considered practicable to manufacture a valve sleeve with holes or annular grooves of sufficiently close accuracy to enable the valve spool to be fitted without adjustment to the land dimensions, except for valves with comparatively large amounts of overlap. Form grinding of the spool is possible, but any form of grinding after hardening is not considered practicable for a normal small sleeve.

It has been found that by far the most convenient method of achieving a high order of accuracy on the valve length dimensions is to adjust the male spool dimensions to suit a selected sleeve. This process (conveniently called "landing,") consists in fitting the sleeve and spool together in a fixture on a flow bench, setting the spool by a micrometer adjustment until one port is just closed, and then measuring the overlap until another port just opens. The spool is then sent to the grinding machine to have the appropriate amount of metal ground off the side of the land being treated. Sometimes fixtures have been rigged up alongside the grinding machine; this has been done for several years in the production of machine tool servos. It undoubtedly offers the best and simplest method of achieving the necessary degree of accuracy.

(*c*) *Flow Characteristics.*—On theoretical grounds, the flow characteristic required for the valve must be a one-to-one relation between the flow and the valve displacement. Further, although on most servos the relation should be linear, on flying controls this is usually not true. In the case of an aircraft flying on auto-pilot, the auto-pilot and other mechanisms have large lags at frequencies much lower than that of the servo, and the gain of the servo can then be pushed to the limit for the benefit of the other dependencies. Thus, the flow valve travel curve may be as shown in Fig. 9. When operating on auto-pilot about the neutral point, the servo reduces to a simple hydraulic amplifier and, in the authors' experience, the time constant for the control can be as small as 10 milliseconds.



——— Upper acceptable manufacturing limit.
– – – – Lower acceptable manufacturing limit.

Available flow variation when plotted about neutral point of valve with a constant pressure of 2800 lb per square inch.

Fig. 9—Flow Displacement Characteristic of Valve Used on an Aircraft Servo

Opinions differ on the optimum method of achieving special flow characteristics. Variations in form of the spool at the land edges, such as tapers, tend to trap dirt and are difficult to "land." A hole pattern on the sleeve can be made easily but at the expense of increased valve travel. Notching of the spool has been used successfully.

(*d*) *Operating Forces.*—As has already been mentioned, the operating forces on the ordinary hydraulic valve are of importance even on comparatively insensitive hydraulic servos. The friction forces which are encountered on practical valves are a considerable inconvenience, the whole character of a servo being upset by the irregular character of the friction. Information has been published elsewhere on this subject in a review of published work (Hadekel, 1952), but further work remains to be done on the relation between friction forces and small particles of dirt. Many hydraulic engineers have observed the phenomenon of "silting"; this arises from the collection of small particles of dirt in the narrow annulus between the valve elements causing an eventual complete blocking of the passage and a large rise in friction. The degree of sealing that can occur with silting is surprising, although the wartime practice, adopted by one hydraulic shop, of stirring the test bed tank to facilitate the acceptance of certain valves by inspection, can scarcely be condoned. Some particularly interesting work on this subject has been done by Blackburn (1949), although there are some who dispute his conclusion that silting can be eliminated completely by the use of suitable "micronic" filtration. Even if, as the authors believe, adequate filtration can prevent small (that is, less than 5 microns) particles of dirt entering the valve, and initial silting troubles, there is some evidence that the valve will eventually generate its own particles of dirt and that it is virtually impossible to eliminate dirt

Notation.

A—Area of jack piston.
B—Viscous damping.
C—Clearance.
D—Diameter of valve.
d_i—Diameter of valve inlet connection.
E—Valve opening.
e—Perturbed valve opening $=\theta_i - \theta_o$.
F—Load, force.
H—Power delivered by valve.
I—Current.
K—A parameter = rate of flow per unit valve opening.
L—Length of valve lands.
M—Mass.
P—Pressure drop across load.
P_s—Pressure drop across supply.
p_c—Perturbed pressure drop.
Q—Flow.
q—Perturbed flow.
s—Laplace operator.
T_1, T_2—Time constants.
t—Time, seconds.
V—Voltage.
v_c—Perturbed piston velocity.
x—Input voltage.
Y_1—Transfer function connecting pressure drop p_c and q.
Y_2—Transfer function between output displacement and pressure drop p_c.
y—Input current
z—Displacement of valve spool.
θ_i—Perturbed part of input signal.
θ_o—Perturbed part of output displacement.
λ_1—A parameter $= \partial Q/\partial E$.
λ_2—A parameter $= \partial Q/\partial P_c$.
μ—Loop gain constant.

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* From a Conference on Hydraulic Servo-Mechanisms. Institution of Mechanical Engineers, February 13th. Extracts.

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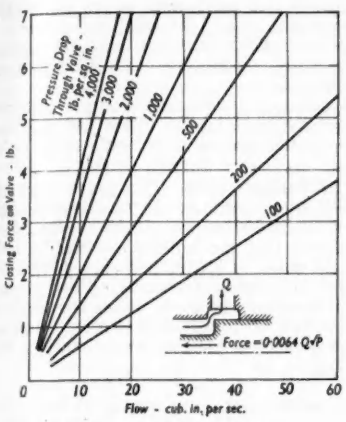
‡ Chief technician British Messier Ltd. Gloucester.

between the filter and the valve itself during assembly.

One common means of eliminating the effects of friction and "stiction" is to introduce a dither or rotational motion to the valve assembly, so that any silting is prevented and lubrication films are distributed as evenly as possible. Introduction of this auxiliary motion is a mechanical complication which should be avoidable by good design, but may be justified on extremely sensitive servos.

The other and perhaps more important source of operating forces on the valve arises from the forces on the valve due to the oil flow through it —the so-called Bernoulli forces. Fig. 10 indicates the not unappreciable order of magnitude



Pressure drop through valve, 100 lb to 4000 lb per square inch.

Fig. 10—Flow or Bernoulli Forces on Valve Spool

of these flow forces for a typical valve. It is only in comparatively recent years that these forces have been examined and studied, and some outstanding work on the problem has been done in the Dynamics Control Laboratory at the Massachusetts Institute of Technology by Lee and Blackburn (1951), resulting in a most ingenious solution for balancing these forces. This system is shown diagrammatically in Fig. 11. The design relies on the creation of a valve opening force due to the return flow from the jack, sufficiently large to balance the closing force due to the inlet flow through the valve to the jack. The flow passing through the return port reacts on the waisted spool section, which has been shaped to create the appropriate neutralising

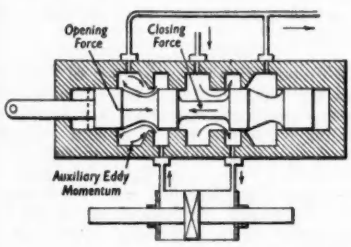


Fig. 11—M.I.T. Dynamically Balanced Four-way Valve

opening force. The exact shape has been determined experimentally, and a remarkable degree of balance achieved. It need not, however, be concluded that the dynamic forces on a valve are, of necessity, always to be avoided. In certain circumstances use may be made of them to stabilise the control.

In most cases, one or two seals will be required at one or both ends of the spool. The friction loads on these seals will not be negligible, and for very light operating loads, seals subjected to high pressure should be avoided if possible ; if one seal is still necessary, it should be of the low-pressure type sealing only against tank back pressure, with a lapped diameter dealing with the main pressure. In many systems the use of seals is avoided entirely, by mounting the whole valve where it can leak back to the reservoir.

To limit the friction of seals, the spool diameter or, at any rate, the diameter on which the seal acts, should be a minimum.

One disadvantage with a three-way valve is the asymmetric operation of the Bernoulli forces. Referring to Fig. 12, in the neutral position the pressure force P is balanced by the spring force F. If the valve is moved to the right then at a steady opening the Bernoulli forces are tending to close the valve, and, hence, act in an opposite manner to the spring. If, however, the valve is moved to the left, then the Bernoulli forces act with the spring. These forces are not inconsiderable, being about 0·7 lb per delivered horsepower when the fluid used is DTD585 and the system pressure is 2500 lb per square inch.

Transducers.—There are many types of electro-hydraulic servo which make use of the power output of the final stage of an electronic amplifier to operate the valve of the hydraulic servo, the available electrical power being of the order of 1W. Since the valve may have an operating force as

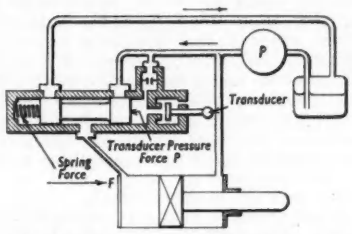


Fig. 12—Flow Forces on Three-way Valve System

high as 1 lb or 2 lb, considerable difficulties may be experienced in obtaining adequate force from the electrical unit, particularly if a large travel is required. Precision valves have been made with an operating force as low as 4 oz, but in practice considerable variations occur due to dirt, &c. The authors, themselves, confess that they do not know how to make a small servo valve which can be relied upon to continue to have an operating load under practical conditions even as low as ½ lb.

Design Pressure

The pressures used on industrial servos as applied to machine tools and steering gear are comparatively low—less than 1000 lb per square inch. Aircraft power flying control servos make use of pressures up to 3000 lb. per square inch, and there appears to be no difficulty in developing small servos to operate at pressures of 4000 lb per square inch or even higher. The effect of pressure does not appear materially to complicate valve design ; the reduction in size of all units for a given power as the pressure increases is indeed an advantage.

The flow through a valve is given by

$$Q = K_1\sqrt{P_s - P_c}.$$

where P_s is the pressure drop across the supply and P_c the pressure drop across the load. Also the power delivered by the valve is K_2QP_c, so that if E is the power rating of the valve

$$H = K_1K_2P_c\sqrt{P_s - P_c}.$$

Differentiating this with respect to P_c gives the interesting result that the valve is delivering maximum horsepower when $P_c = \frac{1}{3}P_s$; that is, when the pressure drop across the valve is $\frac{1}{3}P_s$ and the pressure drop across the load is $\frac{2}{3}P_s$. Thus the maximum power rating is

$$H = 2/\sqrt{3}K_1K_2P_s^{3/2}$$

This gives another indication of the increased efficiency by the use of high pressure.

Performance Testing

A preliminary essential in the development of valves for hydraulic servos is an adequate study of valve flow characteristics and loads. A hydraulic flow bench can be used to determine flow displacement relations, using a micrometer or dial gauge to give valve displacement values. Total flow forces can be measured by means of a rig using a weighted scale arm, but the authors have not yet found a means of separating friction forces from Bernoulli forces with any degree of reliability.

A low-performance servo will probably need to be tested only for positional accuracy, necessitating a comparison of the input and output positions under varying output loads.

A high-performance servo, however, is usually tested under two conditions :—

(1) By the application of a step function input signal ;

(2) With a sinusoidal input signal.

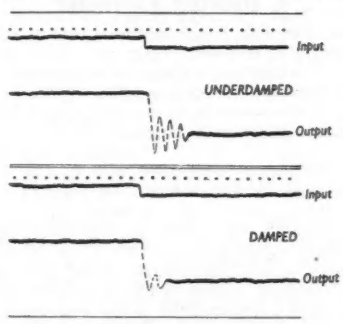
For an electro-hydraulic servo the application of a step function to the input can be carried out electrically by a simple switch circuit. Applying a step function to a mechanical servo, however, is more difficult, and the general method is to apply a rather ill-defined step function in the form of a "hammer" blow to the output shaft. This has been found to be a very successful method of exciting an unstable control.

Typical response curves of a small electro-hydraulic servo to an applied step function are shown in Fig. 13, the step function being applied electrically without difficulty.

The method of harmonic response determination, which is now commonly applied to all high-performance servos, has been found extremely useful, as it facilitates the analysis of defects. The general method is to apply an input signal of true sinusoidal character from some mechanical (simple harmonic motion) generating device, the comparison between the input and output curves being made on an oscilloscope.

A practical servo, as has already been mentioned, will have an output which is out of phase with the input, suffers from attenuation, and has some degree of wave distortion. A convenient method of analysing the records is to plot the degree of attenuation against the logarithm of the frequency, and, similarly, the phase lag against log frequency ; these curves are easy to derive and conveniently simple to understand.

Another method of determining the performance of a servo loop is to draw a Lissajous figure



Time scale, 20-millisecond intervals.

Fig. 13—Typical Step Function Response for Small Electro-Hydraulic Servo

between input and output. In this method an oscilloscope trace is moved in two directions at right angles, respectively by the input and output ; perfect response gives a single straight line of a given amplitude at 45 deg. As the frequency of operation is increased, so the straight line becomes shortened and looped in shape, indicating attenuation, phase lag and wave form distortion. This method is perhaps more difficult to analyse but is convenient for rapid checking of a servo, and may, in fact, be found to be very convenient for routine or production testing.

The effect of the output inertia and load must be determined during testing ; in fact, inertia effects must always be represented, although other varying output loads which have a stabilising effect are usually neglected.

An Indication of the Technique of Improvement

The hydraulic engineer is continually faced with the problem of improving the performance of the servo ; for example, the addition of hydraulic dampers to parts of the system is one method of stabilising an otherwise unstable control in certain circumstances (Bradbury and Parker, 1952). A better method is for the hydraulic engineer to analyse all elements in the servo loop so that he or a mathematical colleague can determine the mathematical transfer functions of the various elements in the

loop ; he can then calculate the instability and confirm theoretically the instability encountered. The next step should be to alter some factor generally associated with the valve characteristic to stabilise the control. If, as occurs on complicated installations of the kind found on aircraft, the trouble may be due to elastic distortions of some parts of the system to which the servo is connected, the cure may involve some comparatively drastic alteration to the installation as a whole.

In the case of electro-hydraulic servos, however, it is possible to compensate for some of the deficiencies in hydraulic performance by electrical means. An example of this is to use an electrical phase-advancing network to compensate for phase lag in the hydraulic part of the system. Another well-known means of improving the performance is to make use of anticipation or derivative control, where the output is responsive to the rate of change of error as well as the error itself. However, discussion of these elaborations goes beyond the intended scope of this paper.

Conclusion

To the hydraulic engineer, one of the most fascinating outlets for such skill as he may have lies in the development of high-performance servo mechanisms. In this age of automatic control and cybernetics he can look forward to the exploitation of every improvement that he makes. If the development of new and improved servo devices does not depend entirely on the arts of the mechanical engineer, it is true to say that the proper degree of reliability which will be essential to the practical extension of automatic control will depend largely on the mechanical engineer, and not a little on the hydraulic engineer.

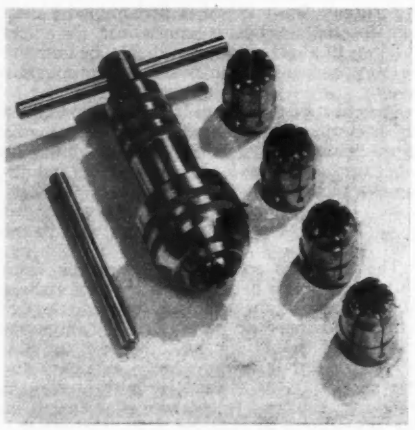
A Bearing Extractor

The illustration below shows an extractor for removing ball and roller races from shafts quickly and without damage to a bearing or the shaft. This tool, which is supplied by the Civitas Trading Corporation, Ltd., 10, Duke Street, London, W.1, is known as the "Tracta" extractor.

The extractor is supplied with a number of collet units to suit different bearing sizes. It has a hollow body with a self-centring chuck to accommodate the collets at one end and a threaded thrust pin at the other. The thrust pin is bored to take intermediate thrust pins which are of different lengths to suit the tool for variations in the distance of a bearing from the end of its shaft. Interposed between the end of the bore in the main thrust pin and the second pin is a ball bearing. This ball bearing prevents the plain pin from rotating as the thrust pin is screwed home, and prevents damage to the end of the bearing shaft.

Collets are made according to the types of bearing and their method of gripping differs slightly when used with ball or roller bearings ; those illustrated are for ball bearings. When removing a ball race the appropriate collet is sprung on to the race so that its teeth register in the ball groove of the inner ring between the ball bearings. With the thrust pin screwed back the body of the extractor is placed on the collet and the chuck tightened to close the teeth and grip them firmly on the bearing. On the thrust pin then being screwed down by means of its tommy bar, it first contacts the end of the shaft and then draws off collet and bearing.

The makers state that this method of removing a bearing by gripping the inner ring does no damage to the ball groove. A range of standard collets is made for use with bearings having races up to some 6in diameter, but special collets can be made for larger sizes if required. The tool can also be used equally well for the removal of taper roller and parallel roller bearings.

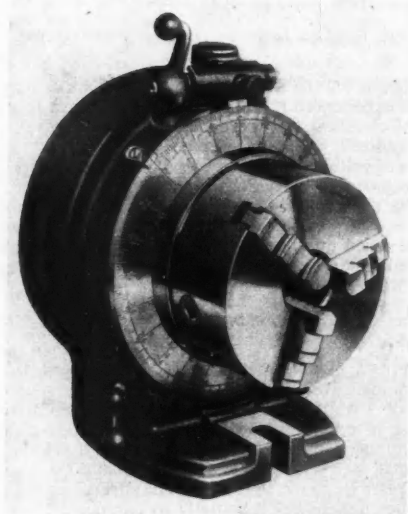


Bearing Extractor and Collets

An Indexing and Dividing Attachment

We illustrate below a recent development of an indexing and dividing attachment for machine shop use, made by W. H. Marley and Co., Ltd., 105, High Road, London, N.11. The unit is adapted for horizontal or vertical mounting. The attachment has a rigid cast meehanite base and is designed to carry an 8in diameter table, a 5¼in capacity chuck, as illustrated, or one of the makers' collet attachments for collets of ¼in to 1¾in diameter capacity.

The standard unit has a twenty-four division index plate, with a top row divided into multiples of three, an intermediate into row multiples of two, and a bottom row marked with the full twenty-four divisions. The lower edge of the index plate is graduated in degrees and numbered at 15 deg. intervals to facilitate angular setting when normal indexing is not required. A spring-loaded indexing pin registers in vee-shaped grooves round the edge of the plate, which is totally enclosed in the base. By using vee-shaped grooves the results of wear in service do not affect the indexing accuracy of the unit. Two locking pins are used to hold the plate firmly in position during machining operations.



Indexing and Dividing Attachment

We are informed that if required index plates can be supplied with any number of indexing notches up to thirty or up to 100 with a special index plunger. All attachments are readily fixed to the base by means of three bolts inserted from the underside.

"The Graduate in the G.E.C."—A booklet entitled "The Graduate in the G.E.C." has been published by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It sets forth the graduate's prospects in the G.E.C., by outlining the facilities which the company, with its forty works, offers for training and experience in an industry employing mechanical engineers as well as heavy-current and light-current electrical engineers and physicists.

French Engineering News

(By Our French Correspondent)

The Ministry of Public Works has asked engineering firms specialising in cleaning materials to design a machine for cleaning the St. Cloud tunnel.

This tunnel is at the entrance to the autoroute de l'Ouest. It is not very long, but owing to the considerable amount of motor traffic passing through it the tiled walls and top are quickly covered with oil and grease. Over the past year, it is estimated, dust inside the tunnel has increased by 70 per cent.

The Ministry states that several cleaning methods have been used. A suction machine was costly and the results were unsatisfactory, as were those when dry cleaning by means of machine turned brushes was tried, and although a jet machine cost less, it failed to clean the tunnel satisfactorily.

At present the walls of the tunnel are being cleaned by hand labour which has been found more satisfactory than machines.

* * *

Trial borings to find coal seams are being carried out in the Jura. In 1953 it is estimated that some 10,000 metres will be prospected. It is believed that the exploitable reserves in the Jura are equal to 150 million tons of rich coal. Several more years of prospecting and planning will be necessary, however, before the seams can be exploited. It is estimated that the whole area would be able to yield between 3000 and 4000 tons daily.

* * *

The public works programme for Morocco to cover the 1953–1956 period, which has now been published, shows that some £15,500,000 will be spent. Work will include a dam at Mechra Hamadi for two hydro-electric plants, one of which will be in Spanish Morocco and the other on French territory. The French plant will have a production capacity of 50,000,000kWh. Irrigation work is to be undertaken at a number of places in the country.

A new canal, at Nifs, will irrigate 40,000 hectares and in drainage work at Gharb 20,000 hectares of land will be reclaimed.

* * *

A large modern garage is to be built on the Quai de Grenelle in Paris. In the construction of this garage there will be used 4000 cubic metres of concrete, 750 tons of steel and 40,000 cubic metres of paint. When completed, the new garage will be 18 metres wide and 28 metres high and 114 metres long. It will take 600 automobiles, which will be stored at five levels reached by a ramp 6 metres wide, A specially-designed terrace roof will be equipped to take helicopters.

* * *

The French High Commissioner of Equatorial Africa has announced that a Franco-American company has been formed for prospecting and exploiting important manganese deposits. Situated west of Franceville, these deposits are said to have a potential of 30,000,000 tons. The percentage of manganese is said to be between 48 and 53 per cent. An annual production, once the company starts, of around 300,000 tons is envisaged. Transport is the greatest problem. It will be necessary to build a 375km railway to serve the ports of Mayamba and Point-Noire. This railway will be used to open up the country and aid both agriculture and the timber industry. The problem at the moment is attracting enough capital to start construction work to enable mining to commence.

* * *

Three important concrete bridges, one of which is already built, are to be the French contribution to the important new road construction plan for Venezuela. The first bridge has a total length of 338 yards, and the two other bridges, which will be completed in June and October, will be 277 yards and 233 yards long respectively. The central span of the first bridge was prefabricated and hauled into position. It weighed 240 tons and had to be lifted 75 yards from the bottom of a valley. French engineers are directing the building of the three bridges, but an American firm is driving the two tunnels, which will be required under the plan.

Industrial and Labour Notes

Coal Output

The saleable output of deep-mined coal last week amounted to 4,348,200 tons. Opencast production was 205,100 tons, making the week's total output 4,553,300 tons. This was about 100,000 tons higher than output in the preceding week, but 20,000 tons or so below the total for the comparable week of 1952. In the first seven completed weeks of this year the saleable output of coal in this country amounted to 32,125,700 tons, which was about 257,000 tons more than in the corresponding period of last year.

In the week ended February 14th, the total number of wage earners on colliery books was 721,000, of whom 299,500 were working at the face, and the shifts worked per wage-earner in the same week are given by the Ministry of Fuel and Power as 4·84. In the corresponding week of last year there were 707,500 on the colliery books, of whom 288,100 were face workers. the shifts worked per wage-earner being 5·07. Total absenteeism in the week ended February 14th was 14·88 per cent, compared with 12·15 per cent a year earlier.

Inland coal consumption in the week ended February 14th amounted to 4,669,000 tons and exports and bunkers took up 292,000 tons, making a total consumption for the week of 4,961,000 tons, compared with 4,877,000 tons in the week ended February 16, 1952. Total distributed stocks of coal on February 14th were 13,340,000 tons compared with 13,650,000 tons a year ago.

Britain's Overseas Trade

The Board of Trade has now announced the final figures for export and import values in the month of January. These figures give the value of exports of United Kingdom goods as £217,700,000, which was just above the monthly average for the fourth quarter of last year. Re-exports were valued at £10,000,000, and the value of imports in January was £290,100,000. The import figure was the highest recorded since last May and was about 10 per cent above the average for the second half of last year.

It is stated that the increase in exports last month over the fourth quarter of 1952 was less than the corresponding increases in January in the two preceding years. But, the Board of Trade says, the small increase in exports suggests that the improvement which was evident in the fourth quarter was maintained in January. The high rate of both ferrous and non-ferrous metal exports which was reached in the fourth quarter continued last month and engineering products, particularly machinery, also continued to do well. The downward movement in exports of vehicles which was shown at the end of last year was checked in January and was reversed in the case of passenger cars. Among other manufactures, exports of refined petroleum reached a value of almost £6,000,000, a figure above that of any preceding month. Exports of raw materials, at £11,200,000, showed an increase of just over £1,000,000, compared with the average in the fourth quarter of last year. Most of that increase was accounted for by bigger coal exports, which were valued at £5,600,000 in January compared with an average of £5,000,000 in the preceding quarter.

Export Prospects

During his chairman's address at the annual meeting of Associated Commercial Vehicles, Ltd., which was held in London on February 18th, Lord Brabazon of Tara made some observations on current export problems, and particularly those experienced by the motor vehicle industry. He said that overseas buyers were now demanding quick delivery and long-term credit as well as a reliable product. To obtain that export business, very severe and ever-growing international competition had to be faced, and there was ample evidence that German, Italian and American manufacturers were prepared to grant much longer credit terms than the British manufacturer was allowed to give by the Government. Future orders in the export market, Lord Brabazon asserted, would depend more and more upon credit facilities, and the British manufacturer was being placed again at a great disadvantage as the working capital necessary to finance those operations had been so severely diminished by the continual drain of high taxation.

Lord Brabazon went on to say that the experience of his group was that there was little help from the Treasury, which dominated the foreign exchange control and the Export Credits Guarantee Department, and which would only authorise relatively short credit terms and high percentage initial payments not generally acceptable in the overseas market to-day. He felt strongly that, unless a much more realistic and less tardy attitude was adopted in authorising export credit guarantees over a longer period, this country would be unable to maintain its export drive. A further fact, Lord Brabazon continued, which had a very important effect on the export market was the question of price. Despite efforts made to economise and to increase the efficiency of factories, the continual demands for increased wages, with the consequential rise in material prices, were so increasing the cost of products that the buyer, in spite of the quality of goods, might in the future not be tempted to buy. It was to be hoped that restraint would be exercised in all quarters, otherwise this country would be priced out of practically every market of the world.

The Price of Coal

At the end of last week, the National Coal Board announced that, as from March 2nd, the pithead price of all coals for inland destinations would be increased by 10 per cent. This represents an average increase of 5s. 6d. a ton.

The Coal Board says that when the last national increase in the pithead price of coal was made at the end of December, 1951, it was intended to meet the rising costs of production, including wages, which were then being experienced. During the past year the Board's wages bill has continued to increase and there have been increases in costs in other directions. In consequence, the Board expects that its accounts for 1952 will disclose a considerable deficit to add to the deficit of £6,000,000 brought forward from preceding years. It is the statutory duty of the Board to balance its revenue and expenditure over good years and bad. As recorded in these notes in our last issue, the Coal Board and the National Union of Mineworkers have agreed to co-operate in measures to increase coal production this year. The Board points out, however, that this co-operation will take time to show its full effects, and meanwhile the pithead price of coal must be increased by 10 per cent in order that the Board may avoid incurring a further loss in 1953. It should be added that the price increase does not apply to exports and foreign bunkers, and that the Board is to bear the increased cost of miners' coal and coal used at collieries.

The campaign agreed upon by the Coal Board and the National Union of Mineworkers, to bring about greater efficiency, opened in South Wales last week-end. In a speech at Cardiff, Sir Hubert Houldsworth, chairman of the Board, said that the country needed an additional 7,000,000 tons of coal this year to meet its obligations. There was now enough manpower in the industry for that additional output to be achieved. Based on last year's output per manshift, Sir Hubert observed, there were now sufficient men in the mines to produce an extra 130,000 tons a week.

Industrial Psychology and Trade Unions

On Tuesday last a meeting of the general secretaries of trade unions was held at the National Institute of Industrial Psychology, in London. It was convened for the purpose of considering the work of the Institute in relation to trade unions.

In welcoming the union secretaries, Mr. E. S. Byng, vice-chairman of the National Institute of Industrial Psychology, spoke of the impartial and objective research into working conditions, both physical and psychological, which the Institute had made in the thirty years or so of its existence. He said that many of the improvements which it had advocated as a result of its early investigations into hours of work, physical conditions, fatigue and working methods were to-day taken for granted and had become standard practice throughout the greater part of industry.

Dr. C. B. Frisby, the director of the Institute, described the development of industrial psychology in this country. He claimed that better vocational guidance, selection and training helped to fit the man to the job and that attention to the physical environment, to the design of tools and machines, and to methods of working and work organisation could make the job more fit for the man. Relationships and communications in the organisation had a most important bearing on satisfaction in work.

On behalf of the trade unions, Mr. H. G. Knight, general secretary of the Association of Supervisory Staffs Executives and Technicians, suggested that industrial psychology could be called the study and analysis of human behaviour, such as the workers' reactions to repetitive tasks, incentive schemes, joint consultation, promotion policies and the many other matters that were the cause of conflict in industry to-day. He went on to say that, to secure her rightful place in the world, Britain must produce more quality goods at lower prices, and to do that there must be a greater measure of industrial co-operation and harmony. If the trade union movement remained aloof from and unaware of the work and results of the National Institute of Industrial Psychology, it might through ignorance oppose and retard methods not only beneficial to its members but also to industrial production in the country. There was still, Mr. Knight observed, much in industry that needed to change and the three forces of workers, employers and scientists could bring about those necessary changes.

Management and the Shop Steward

Last week-end the Industrial Welfare Society held a conference, at Clacton, for foremen and shop stewards. Among the short addresses delivered as a basis for the discussions was one entitled "The Manager Looks at the Shop Steward," by Mr. R. May, general manager of The A.P.V. Company, Ltd., who is a member of the Industrial Welfare Society's Council.

Mr. May said that in the engineering industry, where shop stewards were often militant in action and outlook, the manager tended to look upon them all as unco-operative and as trouble-makers. In other industries, where they were often quite inactive except perhaps for the collection of contributions within the workshop, the manager was very much more friendly disposed towards the shop stewards. But one thing, Mr. May continued, was certain : shop stewards were a force and a rapidly growing one at that, not only within the workshop but also in the trade union movement. Almost every trade union now regarded the shop steward's function as an integral part of its organisation, and management fully realised that this form of representation was by no means at an end.

Whilst, Mr. May commented, there were still some managements which did not officially recognise shop stewards, their numbers were getting fewer, and it seemed to be only a matter of time before all managements would have to recognise and provide facilities for the elected leaders of their organised workers. That being so, it was the manager's duty seriously to examine the functions and activities of the shop steward. He must study the reaction of the shop stewards to the widely recognised need for higher and cheaper production. The manager must also consider, Mr. May added, how best he could help to train and lead shop stewards into active co-operation, and whether he could by any means help to influence the choice of people to fill those positions.

Notes and Memoranda

Rail and Road

DIESEL-ELECTRIC LOCOMOTIVES FOR FRENCH RAILWAYS.—We are informed that the French National Railways have ordered twenty double-six-wheel bogie diesel-electric locomotives, each fitted with a Sulzer twin-bank engine of 2050 b.h.p. maximum output. These engines are to be used for handling all the heavy passenger and freight transfer traffic over the Grand Ceinture lines connecting the various Paris terminal stations.

MOTOR-CAR BRAKES.—At the end of this month Girling, Ltd., Tyseley, Birmingham, completes a period of twenty-one years' service to the motor industry, during which time it has concentrated on the manufacture of brakes, dampers and other chassis equipment. Prior to 1932 the company, which was then known as New Hudson, Ltd., had been concerned with the manufacture of cycles and motor-cycles. It adopted its present name on amalgamating with Joseph Lucas, Ltd., in 1943, and at the same time incorporated the resources of Bendix, another company associated with Joseph Lucas, Ltd.

DIESEL LOCOMOTIVES FOR SUDAN.—Four special eight-wheel diesel-mechanical locomotives are being built by the Hunslet Engine Company, Ltd., for the extensive 2ft gauge railway system of the Sudan Gezira Board. Each of these locomotives is fitted with a McLaren six-cylinder, four-stroke engine with a sea level rating of 132 b.h.p. at 1000 r.p.m. and a site output of 120 b.h.p. at the same speed. Intended for operation in very dusty atmospheres in temperatures up to 120 deg. Fah., and up to 1200ft above sea level, these locomotives are to be used for twenty-four-hour-a-day service throughout the cotton season, with no days off, and a proper overhaul is to be made in the off-season. The locomotives have a maximum tractive effort of 8500 lb and are allowed a top speed of 20 m.p.h. The maximum axle load is 4¼ tons and the total working order weight 16¾ tons.

Air and Water

CANADIAN PACIFIC LINER.—The liner "De Grasse," of 19,665 gross tons, which was built in 1924 by Cammell Laird and Co., Ltd., for the French Line and purchased by Canadian Pacific Steamships, Ltd., to replace the "Empress of Canada," is to be renamed "Empress of Australia."

SUPERSONIC DIVE OF "CF 100" JET FIGHTER.—It has been revealed that the Canadian all-weather day and night twin jet fighter, "CF 100" was recently dived at supersonic speed in the course of its development flying programme. The machine was flown by Jan Zuvakowski and the flight was preceded by about fifteen dives at trans-sonic speed. This machine has a straight wing.

CROSS-CHANNEL AIR FERRY.—The Bristol Aeroplane Company announces that its new Mk. 32 "Bristol" freighter, which is to operate in the cross-Channel air ferry services, operated by Silver City Airways, Ltd., has completed within ten hours' flying all tests necessary for the award of a full Certificate of Airworthiness. The aircraft is the first of six ordered by Silver City Airways, to cope with the traffic on the cross-Channel air ferry routes. Each will be able to carrry three cars (or two of the larger American models), together with twenty passengers and motor and pedal cycles.

FOREIGN AIRCRAFT BARTER.—Seventy standard Gloster "Meteor" jet aircraft have been sold to the Brazilian Air Force for £4,000,000, payable in raw cotton, thus consummating the first barter deal ever made by the British aircraft industry. The Brazilians are selling 15,000 tons of cotton to the British Raw Cotton Commission and the Raw Cotton Commission is establishing a credit for payment of the aircraft. Previously, the Brazilian Government had always purchased aircraft from the United States. This now means that the two largest countries in South America, Argentina and Brazil, have substantial quantities of British jets, the Brazilians having already ordered sixty Mark 8 standard "Meteors" and ten Mark 7 two-seater "Meteor" jet trainers plus spares

AIR TRANSPORT IN 1952.—In 1952, United Kingdom airports handled just under 3,000,000 passengers, of whom over half used London Airport and Northolt. London Airport, with 861,000 passengers, showed an increase of 8 per cent on the previous year; Northolt handled 773,000 passengers, an increase of only 3 per cent. In the past three years, traffic at London Airport has more than doubled. It rose from 395,000 in 1949 to 523,000 in 1950, to 796,000 in 1951, and reached 861,000 in 1952. Outside the London area, Prestwick handled the most passengers—168,000, an increase of 31 per cent. Next in order came Manchester (Ringway), with 161,000 (40 per cent increase); Glasgow, with 157,000 (12 per cent increase); Belfast (Nutts Corner), with 148,000 (10 per cent increase), and Isle of Man (Ronaldsway), with 127,000 (24 per cent increase). Altogether, the provincial aerodromes handled 1·2 million passengers. In the Channel Islands, Jersey Airport had over a quarter of a million passengers (28 per cent increase), and Guernsey 116,000 (27 per cent increase). London Airport increased its freight handling by 6 per cent to 15,300 short tons, taking three-fifths of the air freight handled in the London area as a whole. On balance, however, there was a decline in the volume of freight handled at United Kingdom aerodromes, attributable largely to a drop of more than 3000 short tons in freight picked up and set down at Lympne, where the traffic consists mainly of vehicles. Although substantial increases in passengers and goods moving through the aerodromes was maintained, the number of movements of aircraft engaged on commercial transport operations in 1952 rose by only 5 per cent to 195,400.

THE VICKERS "VISCOUNT 800."—Vickers-Armstrongs, Ltd., and British European Airways have signed a contract for the purchase of twelve new airliners to be designated the "Viscount 800." This order, which, with spares, amounts to more than £4,000,000, brings the number of "Viscounts" sold to more than eighty. It is emphasised that the new "Viscount" is not intended as a replacement for the "Viscount 700." The two aircraft are, in fact, complementary and will give airlines the chance of using the most suitable aircraft for varying stage lengths. In this way the various sections of an airline route pattern can be operated at maximum economy without the high cost of spares, maintenance and training involved when basically different aircraft are used. The essential differences between the "700" and the "800" are a fuselage longer by 160in, permitting the installation of four more rows of passenger seats, and an increase in take-off weight to 65,000 lb, made possible by a developed version of the Rolls-Royce "Dart" propeller turbine engine (to be known as the "R.Da.5"), giving 1540 s.h.p. and 1690 e.h.p. By the continual development of the "Dart" engine from 1000 s.h.p. to the present power, Rolls-Royce, Ltd., has made a vital contribution towards the success of both versions of the "Viscount." The longer fuselage increases the passenger capacity from forty-eight to sixty-six under similar conditions. A high-density version accommodates eighty-two passengers. The twelve aircraft will have been delivered to B.E.A. by October, 1955. B.E.A. have a further eight under option, which means that deliveries of the "800s" to other operators will probably be possible at the end of 1955. The development costs of this new aeroplane are being borne by Vickers-Armstrongs, Ltd.

Miscellanea

"CONTINENTAL GAS TURBINES, 1952."—In an article in our issue dated February 13, 1953, we illustrated, on page 251, a gas turbine at Dudenlange. This set has an output of 5·4MW instead of 4·5MW, as stated in the caption.

"DUCTER" LOW-RESISTANCE TESTING SET.—A handbook (No. 269), published by Evershed and Vignoles, Ltd., Acton Lane Works, Chiswick, London, W.4, describes the principle of the "Ducter" low-resistance test set and gives examples of its use.

FRENCH PETROLEUM CHEMICAL PLANT.—Jointly owned by the Shell Petroleum Company, Ltd., and the Société de Saint-Gobain, a petroleum-based solvents plant was opened at Berre, near Marseilles, on January 29th. The plant, which is the first of its kind in France, will use propylene gas obtained from a nearby petroleum refinery to produce annually 7500 tons of acetone and solvents.

THE VARLEY COIL DESIGNERS' HANDBOOK.—"The Varley Coil Designers' Handbook," published by Oliver Pell Control, Ltd., Cambridge Row, Burrage Road, Woolwich, S.E.18, is a fourteen-page illustrated booklet containing information for the use of coil designers. The subject matter includes insulating materials and coil finishes, design formulæ for a.c. and d.c. coils, and temperature rise. There is a useful table for coil calculation showing the resistance weight and ratings corresponding to various coverings and gauges of wire.

ACETYLENE PLANT.—We have been informed by Head Wrightson Processes, Ltd., that the Fluor Corporation, which it represents, has been authorised by the Wulff Process Company to design and construct plant for the application of the Wulff process. This uses natural gas, ethane, propane, butane or any liquified petroleum gas as feed stock to produce low-cost acetylene. The process may be applied to plants having an acetylene production capacity ranging from 1 ton to 100 tons per day, and can be used to yield simultaneously commercial grade ethylene.

ROYAL PHOTOGRAPHIC SOCIETY'S CENTENARY.—The Royal Photographic Society, which celebrated its centenary on January 20th, is holding an exhibition of photographs from the Society's permanent collection and of photographic apparatus at the Science Museum, Exhibition Road, S.W.7, until March 28th. The exhibits include a variety of early and modern cameras and lenses and experimental apparatus used by Hurter and Driffield, Friese Greene, and other pioneers. A further collection from the Society's permanent collection is on view at 16, Princes Gate, S.W.7.

EVALUATION OF RESTRIKING VOLTAGE SEVERITY.—A booklet, "Interim Rules for the Evaluation of Restriking Voltage Severity" (ASTA No. 13), has been published, price 5s., by the Association of Short-Circuit Testing Authorities, 36, Kingsway, London, W.C.2. Its purpose is to provide a means for making comparisons, on a uniform basis, during the testing of circuit breakers in ASTA (Association of Short-Circuit Testing Authorities) stations. It sets out to overcome the difficulties that arise when comparing the severity of circuits that produce restriking voltage transients having widely different wave forms.

BRITISH PETROLEUM EQUIPMENT.—The winter, 1953, issue of *British Petroleum Equipment News* contains an article dealing with Great Britain as a source of supply of petroleum plant and equipment, which in terms of value has increased from £14,000,000 in 1945 to £84,000,000 in 1951. A list of British Standard Specifications for equipment suitable for the oil industry is included, together with the corresponding American Standard. There is a description of the air heating and control installation of a synthetic fluid catalyst plant and some account of the post-war refinery expansion programme in Europe of the Shell Petroleum Company, Ltd.

FRICTIONAL SPARKS IN A COMPRESSED-AIR MOTOR.—The Safety in Mines Research Establishment has issued a research report by Mr. W. Thompson and Mr. H. Titman, entitled, "Incendivity of Frictional Sparks Produced Within a Compressed-Air Motor and Expelled in the Exhaust." A 9 h.p. compressor-air motor used in drilling long bore-holes was observed to eject sparks from the exhaust. Examination showed that within the motor there were no metal-to-metal friction surfaces and it was deduced that the sparks were caused by adventitious particles carried along in the air stream and heated by friction within the motor. It was found that rust injected into the pipes produced showers of similar sparks. Fine rust of less than 500 microns gave more sparks than an equal weight of coarser rust of 500 to 1270 microns. Coarse and fine coal dust gave no sparks. Tests were made in which the sparks were ejected into an explosive mixture of methane and air, but no ignitions were obtained. Tests were carried out in which the motor was surrounded by an explosive mixture and was also driven by a similar mixture of methane and air. There was no ignition of the mixture.

MACHINE TOOL PRODUCTIVITY REPORT.—We have received a note from David Brown Machine Tools, Ltd., of Manchester, which states that whilst agreeing with certain suggestions contained in the productivity team report, it strongly rejects several criticisms of British manufacturing methods. Replying to the statement in the report that the machine tool industry in the United Kingdom pays more attention to "window dressing" of its products than does the American industry, the company points to the fact that the American machine tool industry is largely catering for the home market only. Current figures show that American manufacturers export about 15 per cent of their products, whereas 45 per cent of the machine tools made in Britain are exported. Moreover, experience has proved that, generally speaking, the home market appears to be satisfied with a finish which would not normally be accepted in other countries. Another factor relating to this question of finish arises from the increasing competition which British manufacturers are experiencing from continental countries. The firm also comments on the report's implication that British manufacturers place unnecessary emphasis on accuracy. The company is mainly concerned with the production of high-speed turbine hobbing machines, most of which are built to British Standard Specification, plus, in many cases, the requirements of the Admiralty and the National Physical Laboratory. Thus, the limits of accuracy are predetermined by higher authority. One important point on which the firm concurs with the report is the suggestion that production could be increased by simplification, standardisation and specialisation. Simplification could readily be achieved on machine tools used for mass production work, particularly if the machine could be designed round a single or relatively small number of production components. However, it is pointed out that automatic motions which are designed to speed production and relieve manual operation tend to make a machine more complicated and consequently more difficult to maintain.

Personal and Business

C.A.V., Ltd., Acton, N.W.3, announces the appointment to its board of directors of Mr. G. G. Savill and Mr. L. R. Johnston.

MATTHEW HALL AND CO., Ltd., announces that Mr. W. D. Mitchell has joined Matthew Hall (Pty.), Ltd., Johannesburg, South Africa, as general manager.

BAKELITE, Ltd., announces the following appointments: Mr. W. E. Pattman, purchasing manager; Mr. J. M. Lassen, sales manager, Vybak P.V.C. materials.

JOHNSON AND PHILLIPS, Ltd., Charlton, S.E.7, states that Mr. Frank Greenshields, has left for Australia to take up duties at its branch in Sydney.

MR. G. B. ALVEY has been appointed a director of Mather and Platt, Ltd., Manchester. He will continue to be responsible for the work of the company's electrical department.

THE BRITISH ELECTRICITY AUTHORITY announces that Mr. C. A. Smeed, retired on February 7, 1953, from the position of civil engineer and architect, Eastern Division.

LORD LATHAM, chairman of the London Transport Executive, has informed the Minister of Transport that he has decided to return to his professional practice when his present term of office expires at the end of September.

MR. JOHN MCLAREN, has established a consulting practice at 20, Dudley Road, Tunbridge Wells, Kent (telephone, Tunbridge Wells 919), specialising in architectural acoustics, light industrial building design, electrical installation and heat insulation work.

SPECIALLOID, Ltd., and AERO PISTON RING, COMPANY, Ltd., announces that Mr. Peter B. Higgins, has been appointed to the boards of both companies. Mr. R. H. Hainsworth has been appointed managing director and Mr. T. O. Hunt a technical director of Specialloid, Ltd.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2, announces the following appointments: Mr. F. R. Livock, Controller—Education and Personnel Services, and Mr. G. B. L. Chivers, staff manager of the sales organisation.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

METALLURGY

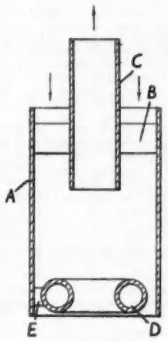
686,952. April 26, 1951.—WELDING RODS, Eutectic Welding Alloys Co., Ltd., Abbey House, Victoria Street, London, S.W.1.

The invention relates to welding rods for use in the welding of copper and alloys of high copper content. A typical example of a welding rod in accordance with this invention, which has been found very satisfactory in use is one in which the rod proper consists of 99 per cent of nickel and 1 per cent of copper provided with a flux coating of the following composition: carbonaceous material, 8 lb; calcium carbonate, 40 lb; calcium fluoride, 55 lb, and sodium silicate as a binder, in a quantity necessary to make either a dipping solution or heavy paste for extrusion process, the quantity being not less than 14·7 lb.—*February* 4, 1953.

DUST SEPARATORS

687,096. November 9, 1951.—REVERSE FLOW CYCLONE DUST SEPARATORS, Richard Fritz Heinrich, 10, Dunmore Road, Gatley, Cheshire.

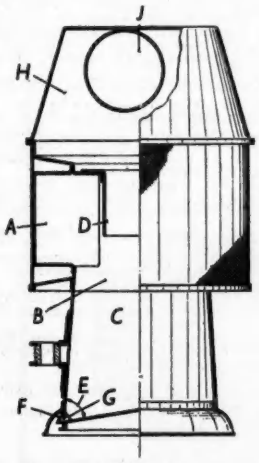
As the drawing indicates, the dust-laden gas enters at the top of the cyclone tube *A* and flows in a helical path through guide blades *B*, after which it leaves by the central tube *C*. The dust is thrown to the wall of the tube *A* and leaves at the bottom. In the outlet end of the tube there is fitted a ring *D* of circular cross-section, which is supported in a central position by three brackets *E*. The dust passes between the ring and the tube and any air it retains returns through the central opening of the ring to the outlet tube.—*February* 4, 1953.



No. 687,096

687,012. June 9, 1950.—CENTRIFUGAL DUST SEPARATORS, Knecht G.m.b.H., 48, Haldenstrasse, Bad Cannstatt, Stuttgart, Germany.

The drawing shows an elevation of a centrifugal dust separator for engines requiring a large air supply. During the suction stroke of the engine the air enters through the inlets *A* and flows through the centrifuging chamber *B*, in which it circulates at a high velocity, the greater part of the impurities being thrown outwards. The bulk of the impurities pass along with the stream of air travelling downwards in a spiral into the settling chamber *C*, and separates from it, whilst retaining the direction of motion. The purified stream of air, on the other hand, reverses, forming an eddy dip, and escapes through the pipe *D*. The bulk of the separated material flows into the gutter *E* and passes along the baffles *F* and out through the apertures *G*. On the top of the separator is the conical expansion chamber *H*, with a pipe *J* delivering the clean air to the engine. *February* 14, 1953.

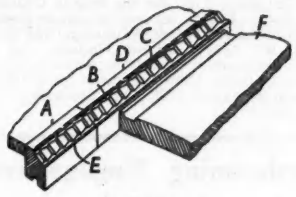


No. 687,012

ROAD TRANSPORT

686,832. September 21, 1949.—ROAD KERBS AND EDGINGS, Niall Dingwall Hodge, Bankhead Farm, Coatbridge, and Alexander Cumming Rutherford, The Grange, Lenzie, Glasgow.

As shown in the drawing, *A* represents the kerb blocks and *B* a face which is formed with serrations or flutings *C*, which have also plane surfaces *D*. This face *B* is set at an angle to the vertical of not less than 35 deg., nor more than 55 deg. *E* is the longitudinal edge of the kerb, and *F* the surface of the roadway. It has been shown that a greater proportion of light is reflected back to the driver of an oncoming vehicle from the lamps of that vehicle by the plane surfaces *D* of the serrations or flutings *C*, which are arranged on the inclined surface. In addition to the drawing shown, there is another drawing with the flutings arranged at an acute angle to the edge of the kerb and the oncoming traffic.—*February* 4, 1953.



No. 686,832

SHIPBUILDING AND STRUCTURAL ENGINEERING

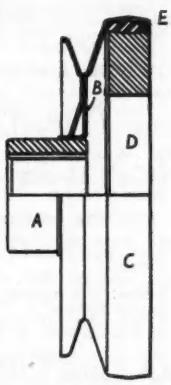
686,312. October 24, 1949.—RIVETS AND RIVETING, Schori Metallising Process, Ltd. (*Inventor: Claude Albert Robiette.*)

The invention concerns an improved rivet and method of riveting. In shipbuilding and structural engineering when ordinary steel rivets are used considerable corrosion is often found under the head of the rivet. With the object of overcoming this defect, the invention uses a steel rivet which has been coated with aluminium or an aluminium alloy, consisting of aluminium and nickel-chrome or cadmium. When such coated rivets are heated to the temperature usually employed for riveting, namely, 800 deg. to 950 deg. Cent., the coating material diffuses into the steel and so forms a heat and corrosion-resisting layer. The coating may be applied to the rivets by metal spraying using the Schori pistol.—*January* 21, 1953.

VIBRATION ABSORBERS

686,976. November 20, 1951.—TORSIONAL VIBRATION ABSORBERS, The General Tire and Rubber Company, 1708, Englewood Avenue, Akron, Ohio, U.S.A.

The invention relates to torsional vibration absorbers for application to engine crankshafts. The drawing shows the upper half of a torsional vibration absorber made in the form of a wheel keyed to the shaft whose vibrations are to be absorbed. The wheel has a hub *A* to which is attached a wheel body in the form of a disc *B* provided with a laterally projecting peripheral flange or rim *C*. The wheel may serve as a belt pulley as well as a vibration absorber, as shown. Within the rim *C* of the wheel is mounted an inertia member *D* which is relatively heavy and which may be in the form of a ring or annulus. The inertia member is supported concentrically within the rim and spaced laterally from the wheel body *B* by means of a ring *E* of rubber. When it is desired that the device has a relatively high resonant torsional frequency, it is advantageous to have the ring *E* under circumferential tension. The manner of assembling the rubber ring is also described in the specification.—*February* 4, 1953.

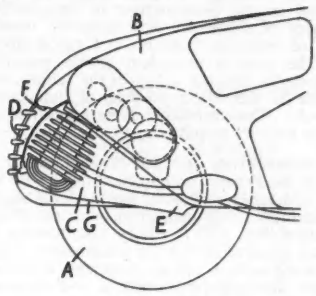


No. 686,976

INTERNAL COMBUSTION ENGINES

687,042. March 22, 1951.—AIR-COOLED ENGINE IN A MOTOR VEHICLE, Hermann Klaue, Uberlingen/Bodensee, Germany.

The invention relates to the problem of using air-cooled engines in small motor vehicles without cooling fans. The drawing shows a longitudinal section through the air-cooling channel provided in the front portion of the motor vehicle. *A* is a front wheel and *B* the vehicle body with a cooling duct *C*. At the front of the vehicle body is an air entrance *D*, and in the underside of the body there is an exit opening *E*. The cylinders of the engine project downwards into the cooling duct. The cooling air is guided by a plate *F* separating the cooling duct from the engine parts. The lower wall of the cooling duct is formed by a guide plate *G*. As a high pressure exists at the front of the vehicle when moving forward and a high vacuum exists over the front third of the underside, the cooling air is sucked in through the front opening *D* of the cooling duct *C*. The air stream cools the engine cylinders so effectively that a cooling fan is not required, thus reducing the load on the engine.—*February* 4, 1953.

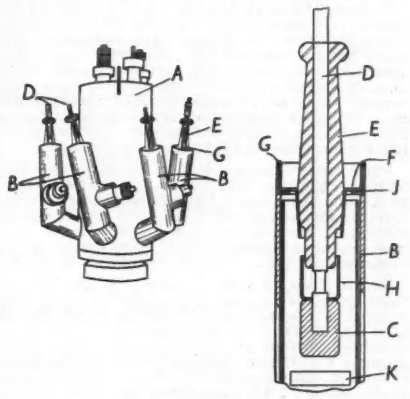


No. 687,042

ELECTRICAL ENGINEERING

684,480. May 26, 1949.—MERCURY ARC RECTIFIERS, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2.; and John Hubert Holliday and Cecil Francis Machin, both of the company's Research Laboratories, Wembley, Middlesex.

The invention relates particularly to high-voltage steel-clad mercury arc rectifiers for providing a direct-current output voltage at least in excess of 3000V, but at a relatively low current value—say, less than 50A. Referring to the drawings, the rectifier is a six-phase steel-clad pumpless unit, the size of the tank *A* being 2ft 6in long by 8in diameter with external steel side arms *B*. Each anode *C* is of graphite, mounted in its tubular side arm by a solid glass seal consisting of a central rod *D* of a nickel, cobalt, iron alloy sealed in an elongated part *E* of glass of the correct coefficient of expansion to match the alloy and generally of double truncated conical shape. The outside of the glass part *E* is sealed to a conical cup *F*, also of a nickel, cobalt, iron alloy, welded at its top rim *G* into the open end of the steel side arm *B*. The anode is screwed on to the inner or lower end of the rod *D* and a protective steel cup *H* extends from the top of the anode around the bottom of the seal of the glass part *E* to the rod *D* and a protective steel cup *H* extends from the top of the anode *C* around the bottom of the seal of the glass part *E* to the rod *D* and another protective steel cup extends a short distance from the inside of the arm and the flange of the cup rests on a spacing washer *J*. The anode supporting rod conducts heat away from the anode and its size and shape are chosen so that the anode temperature is not so high as to avoid causing emission on inverse volts, but is sufficiently high to prevent condensation of mercury on the anode. Grids *K* are mounted one in front of each of the anodes for output control. Experience with the experimental rectifier shows that for still higher voltages it would probably only be necessary to increase the size of the anode arms *B* to allow for insulation to withstand the higher voltages and, if necessary or desirable, the space between an anode *C* and its side arm *B* could be subdivided by metal shields.—*December* 17, 1952.



No. 684,480

Technical Reports

The Measurement of Permittivity at High Frequencies. By E. Rushton (National Physical Laboratory). The British Electrical and Allied Industries Research Association (Ref. L/T252). Price 6s., postage 3d.—The report discusses the errors which may arise in the measurement of permittivity at frequencies of about 50 Mc/s upwards, when the method of reactance variation in a tuned circuit is used. The error is dependent on the permittivity of the material and the radius of the sample, and is attributed to the effects of residual inductance in the circuit. The corrections to be applied in order to obtain the true permittivity are evaluated.

The Measurement of Lightning Currents: A Survey of the Present State of Knowledge. By R. H. Golde, A.M.I.E.E., and T. J. Brown, A.R.C.S., B.Sc. The British Electrical and Allied Industries Research Association (Ref. S/T57). Price 12s., postage 4d.—It is now recognised that the information available on the amplitudes of lightning currents is subject to a certain ambiguity and that a re-evaluation of available data is advisable. In the present report existing information is critically examined and it is concluded that additional data are required, particularly on the upper and lower limits of lightning current amplitudes. For this purpose, a new installation of magnetic links on lightning conductors is being undertaken. A new method for evaluating possible current reversals in the lightning discharge is also discussed.

Contracts

THE ANGLO-SAXON PETROLEUM COMPANY, Ltd., has placed the order to build the first oil tanker to be propelled by gas turbines with Cammell Laird and Co., Ltd. The machinery for the 18,000-ton deadweight ship, which will be built jointly by British Thomson-Houston Company, Ltd., and the shipbuilders, will consist of two gas turbo-alternator units driving a single propeller through two electric motors and a two-pinion, single-reduction gearbox. Each open cycle unit will have two-stage compression with intercooling, and the h.p. unit will include a turbine, compressor and geared auxiliary alternator and exciter set, while the l.p. unit will consist of a turbine, compressor and propulsion alternator. Steam turbines, each of 150 h.p., will start the gas turbines. The design and testing of the machinery will be carried out by the British Thomson-Houston Company, Ltd.

Launches and Trial Trips

EDOUARD BRANLY, passenger liner; built by the Ateliers et Chantiers de la Loire for the Maritime des Chargeurs Reunis Cie; length between perpendiculars 502ft, breadth moulded 64ft 4in, depth moulded to upper deck 41ft, draught 27ft 11in, displacement 17,500 tons, deadweight over 9000 tons, speed 17 knots; passengers, 91 first and 52 second class, 398 troops or steerage; two Sulzer single-acting, two-stroke diesel engines, eight cylinders, 720mm diameter by 1250mm stroke, 10,000 b.h.p. (total) at 120 r.p.m. Trial, January.

EDDYCLIFF, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for the Naval Store Department of the Admiralty; length between perpendiculars 270ft, breadth 44ft, moulded depth 18ft 6in, deadweight 2000 tons; steam-driven deck machinery, one set of triple-expansion engines, built by Lobnitz and Co., Ltd. Trial, February 10th.

BRITISH FLAG, oil tanker; built by R. and W. Hawthorn Leslie and Co., Ltd., for the British Tanker Company, Ltd.; length overall 547ft, breadth moulded 69ft 6in, depth 37ft 6in, deadweight 16,200 tons; Hawthorn-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6400 b.h.p. at 115 r.p.m., two auxiliary boilers, two 150kW diesel generators, one 75kW steam-driven generator. Launch, February 12th.

NORDELITE, motor trawler; built by the Goole Shipbuilding and Repairing Company, Ltd., for the Saint Andrew's Steam Fishing Company, Ltd.; length 105ft, breadth 23ft 6in, depth 11ft 6in; Crossley diesel engine, 450 b.h.p. at 310 r.p.m. Launch, February 16th.

M.S.C. ROVER, tug; built by Henry Robb, Ltd., for the Manchester Ship Canal Company; length overall 95ft, breadth moulded 24ft, depth moulded 12ft; two Crossley diesel engines, total output 1200 b.h.p. at 250 r.p.m. Launch, February 17th.

BINNA, cargo ship; built by Hall, Russell and Co., Ltd., for Fred Olsen and Co., Oslo; length between perpendiculars 265ft, breadth moulded 44ft, depth moulded to main deck 19ft 3in, deadweight 2500 tons on 16ft 10in summer draught; two holds, four hatches, steam deck machinery; Hall, Russell-Fredrikstad No. 6 double-compound, four-cylinder steam motor, taking superheated steam at 220 lb per square inch and 600 deg. Fah. from two single-ended cylindrical boilers. Trial, February 14th.

TAHITVEN, passenger liner; built by the Navy Yard, Brest, for Messageries Maritimes; length between perpendiculars 511ft 10in, breadth moulded 67ft 7in, depth moulded to "C" deck 50ft 10in, draught loaded 25ft 7in, displacement 17,500 tons, deadweight 9350 tons, speed 17 knots; passengers, 71 first, 84 tourist, 86 third and 122 fourth class; six holds; two Schneider-B. and W., two-stroke, single-acting diesel engines, ten cylinders, 620mm diameter by 1150mm stroke, total service horsepower 7000 b.h.p. Trial, February.

GLENMOOR, cargo liner; built by R. and W. Hawthorn Leslie and Co., Ltd., for the Moor Line, Ltd.; length between perpendiculars 423ft, breadth moulded 58ft, depth moulded to upper deck 29ft, deadweight 9350 tons, draught 25ft 8½in, service speed 13 knots; five cargo holds, arranged for carriage of grain; steam deck machinery; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m., two auxiliary boilers, two 40kW steam-driven generators. Trial, February 17th.

NICOLAS, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for the Parana Compania de Vapores S.A.; length between perpendiculars 530ft, breadth moulded 72ft 9in, depth moulded 38ft 8in, deadweight 18,500 tons; Kincaid-Harland and Wolff-B. and W. two-cycle, single-acting, opposed-piston diesel engine, six cylinders, 750mm diameter by 2000mm combined stroke, heavy fuel, 7500 b.h.p., two boilers. Launch, February 18th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., March 2nd.—LEEDS BRANCH: Great Northern Hotel, Leeds "From Nebula to Man," W. L. Whittle, 7.30 p.m.
Tues., March 3rd.—S.E. LONDON BRANCH: Congregational Church Hall, Court Road, Eltham, "Television Production," 8 p.m.——W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "Floodlighting of Sports Arenas," A. C. Holden, 7.30 p.m.
Thurs., March 5th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "Electrical Installations," W. F. Parker, 8 p.m.
Fri., March 6th.—LIVERPOOL BRANCH: Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool, 2, "The Effect of Electric Shock on Humans," D. A. Picken, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., March 5th.—SCOTTISH SECTION: The University, Glasgow, "Electronics in Nuclear Research," J. M. Reid, 7 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., March 2nd.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Utilisation of Water in Iron and Steel Works," W. H. Tubbs, 6.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., March 3rd.—STOKE-ON-TRENT GROUP: Midlands Electricity Board, 31, Kingsway, Stoke-on-Trent, "Lighting of Television Studios," 6 p.m.
Wed., March 4th.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, 1, "Luminescence as Applied to Lighting," H. G. Jenkins and A. H. McKeag, 6.15 p.m.
Thurs., March 5th.—NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "The Lighting of Power Stations," L. H. Hubble, 6 p.m.——EXETER GROUP: Providence Hall, Northernhay Street, Exeter, "Outdoor Illumination," H. A. Turner, 7 p.m.
Fri., March 6th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board Lecture Theatre, Colston Avenue, Bristol, "Outdoor Illumination," H. A. Turner, 5.30 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Feb. 27th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "The Development of Mechanical Excavators," L. V. Nelson; "Modern Crawler Tractors," G. H. Shaw, 7.30 p.m.
Tues., March 3rd.—S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, Lecture and Discussion on "Gland Packing versus Mechanical Seals," 7.15 p.m.
Thurs., March 5th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Modern Refrigeration," 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., March 2nd.—S.E. Essex Technical College, Dagenham, "Photo-Elasticity," J. Ward, 7 p.m.

INSTITUTE OF PETROLEUM

Mon., March 2nd.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Production and Utilisation of Petroleum Raw Materials in the U.K. Chemical Industry," 10 a.m. to 7.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., March 2nd.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Transport and the Engineer," T. P. Rankin, 7.30 p.m.
Tues., March 3rd.—N.W. CENTRE: Station and Victoria Hotel, Preston, "The Running Maintenance of C.I. Engined Commercial Vehicles," T. Charlesworth, 7.30 p.m.——EASTERN CENTRE: Marshalls Airport, Cambridge, "Palletisation and the Fork-Lift Truck," E. Wood, 7 p.m.

INSTITUTE OF WELDING

Wed., March 4th.—MANCHESTER BRANCH: Reynolds Hall, College of Technology, Manchester, "Pressure Welding," A. B. Sowter and R. K. Hilton, 7.15 p.m.
Thurs., March 5th.—N.E. (TYNESIDE) BRANCH: Mining Institute, Neville Hall, Newcastle upon Tyne, "Welding in Heavy Machinery," E. C. Houghton, 7 p.m.——EASTERN COUNTIES BRANCH: Lecture Hall, Electric House, Ipswich, "The Abbey Steelworks," W. S. Atkins.

INSTITUTION OF CIVIL ENGINEERS

To-day, Feb. 27th.—YORKSHIRE ASSOCIATION: Royal Station Hotel, York, "Claerwen Dam, Design and Construction of 200ft High Gravity Dam," P. Scott, 7 p.m.
Tues., March 3rd.—AIRPORT MEETING: Great George Street, Westminster, London, S.W.1, "Methods of Soil Stabilisation and Their Application to the Construction of Airfield Pavements," D. J. Maclean and P. J. M. Robinson, 5.30 p.m.
Thurs., March 5th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "The Disarmament of Krupps, Essen," I. Davidson, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Monday, March 2nd.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Review of Electricity Applied to Mining," B. L. Metcalf, 6 p.m.
Tues., March 3rd.—MEASUREMENTS AND RADIO SECTION: Savoy Place, London, W.C.2 "The Study of a Magnetic Inverter for Amplification of Low-Input-Power D.C. Signals," E. H. Frost-Smith; "The Parallel-T.D.C. Amplifier: A Low-Drift Amplifier with Wide Frequency Response," P. S. T. Buckerfield, 5.30 p.m.——S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Cresent, Glasgow, C.2, "The Place of Steam, Water and Wind Power in an Integrated Scheme for the Generation of Electricity," C. W. Marshall, A. Feiner and J. Venters, 7 p.m.
Thurs., March 5th.—JOINT MEETING with the INSTITUTION OF MECHANICAL ENGINEERS, Savoy Place, London, W.C.2, "Design Features of Certain British Power Stations," S. D. Whetman and A. E. Powell, 5.30 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., March 3rd.—COVENTRY BRANCH: Room A.5, Technical College, Coventry, "The Atom in Engineering," H. C. Smith, 7.30 p.m.——S.W. BRANCH: Grand Hotel, Broad Street, Bristol, "Precision Engineering Measurement," W. H. Foster, 7.30 p.m.
Wed., March 4th.—BIRMINGHAM BRANCH: Chamber of Commerce, New Street, Birmingham, "The Heat-Treatment of High-Temperature Materials," T. E. Cound, 7.30 p.m.
Thurs., March 5th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.1, "Manufacture, Inspection and Erection of Oil Refinery Equipment," A. W. Mason, 6 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

To-day, Feb. 27th.—Robert Gordon's Technical College, Aberdeen, "Textile Finishing Machines," K. S. Laurie, 7.45 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 27th.—GENERAL MEETING arranged in conjunction with the INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP: Storey's Gate, St. James's Park, London, S.W.1, "Developments in Steel Castings in the Heavy Power Plant Industry," F. Buckley, 5.30 p.m.——WESTERN BRANCH, GRADUATES' SECTION: Grand Hotel, Bristol, "Research Methods in the Commercial Gas Turbine Field," M. E. Ginniff, 7 p.m.
Tues., March 3rd.—MIDLANDS BRANCH: College of Technology and Arts, Eastlands, Rugby, "Water Turbine Governors," N. G. Dennis, 6.30 p.m.——S. WALES BRANCH: S. Wales Institute of Engineers, Cardiff, "Welding in Marine Engineering," H. N. Pemberton, 6 p.m.——COVENTRY A.D. CENTRE: Craven Arms Hotel, Coventry, Annual General Meeting, 7.15 p.m.
Thurs., March 5th.—JOINT MEETING with the INSTITUTION OF ELECTRICAL ENGINEERS: Savoy Place, London, W.C.2, "Design Features of Certain British Power Stations," S. D. Whetman and A. E. Powell, 5.30 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Accounting Machines and Systems," F. Pilling, 6.45 p.m.
Fri., March 6th.—GENERAL MEETING arranged in conjunction with the STEAM GROUP: Storey's Gate, St. James's Park, London, S.W.1, series of papers from the Parsons and Marine Engineering Turbine Research and Development Association, dealing with Steam Turbine Research and Development Work carried out at its Research Station, 10.30 a.m., 2.30 p.m. and 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, Annual General Meeting, "Significant Changes in Trades Union Outlook Over the Last Decade," D. Russell, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., March 4th.—Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "The Problem of Supervision in the Post Office," F. B. Wilcher and J. Meade, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., March 4th.—COVENTRY SECTION: Church House, Church Street, Rugby, "The Manufacture of Components from Powdered Metals," W. D. Jones, 7 p.m.——EDINBURGH SECTION: North British Station Hotel, Princes Street, Edinburgh, "Jottings from a Designer's Notebook," J. A. Horne, 7.30 p.m.——NOTTINGHAM SECTION: Victoria Station Hotel Milton Street, Nottingham, Annual General Meeting, followed by films, 7 p.m.
Thurs., March 5th.—GLASGOW SECTION: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting and Open Discussion on "The Possibilities of Radial Drilling," led by M. C. Timbury, 7.30 p.m.——LEICESTER SECTION: Windsor Room, Bell Hotel, Leicester, Annual General Meeting and Film, 7 p.m.——LONDON SECTION: Old Ship Assembly Rooms, Brighton, "Measurements in Gear Manufacture," R. D. B. Stone, 7 p.m.——READING SECTION: Great Western Hotel, Reading, "British Watch and Clock Production," R. Lenoir, 7.15 p.m.
Fri., March 6th.—SOUTHERN SECTION: Polygon Hotel, Southampton, Annual General Meeting, 7 p.m.——W. WALES SECTION: Central Library, Alexandra Road, Swansea, "The Development of Sheet and Tinplate Mills: The Function of Lubricants and Process Oils," W. Williams, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 27th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "Experiences with Concrete," N. T. Grant, 6 p.m.
Tues., March 3rd.—N. IRELAND BRANCH: College of Technology, Belfast, Recent Developments in Prefabricated Concrete Structures," J. C. Malcolmson, 6.45 p.m.
Thurs., March 5th.—WESTERN COUNTIES BRANCH: The University, Geology Lecture Theatre, University Road, Bristol, "Plymouth 'B' Power Station," L. Richardson, 5.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 27th.—Townsend House, Greycoat Place, London, S.W.1, "Electronics in Materials Handling," L. Landon Goodman, 7 p.m.
Wed., March 4th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Air and the Future," F. R. Banks, 7 p.m.
Fri., March 6th.—Townsend House, Greycoat Place, London, S.W.1, Film Evening, "Highlights of Farnborough, 1952," and "Fire Power and Octane," 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Feb. 27th.—Engineers' Club, Albert Square, Manchester, "The Testing of Motor Vehicles," G. H. Swindlehurst, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 27th.—Mining Institute, Newcastle upon Tyne, "Wave Studies of Plane Surfaces," J. F. Allan and R. S. Cutland, 6.15 p.m.

ROYAL SOCIETY OF ARTS

Wed., March 4th.—John Adam Street, Adelphi, London, W.C.2, "The Assessment of Suitability for Employment," C. B. Frisby, 2.30 p.m.